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Individual Differences in Imagery

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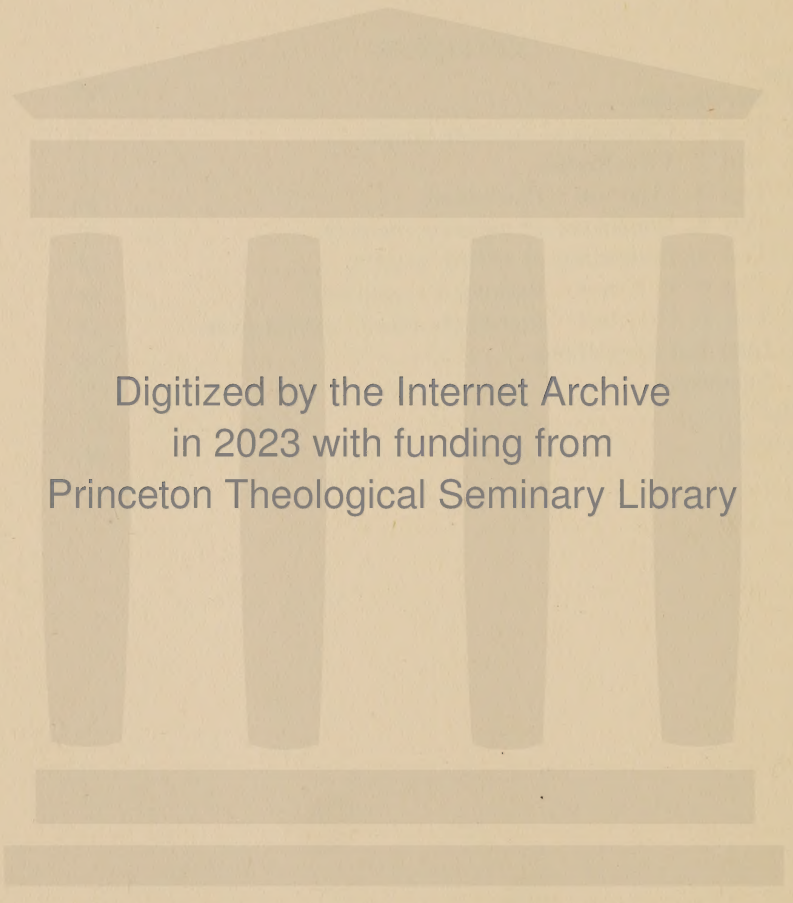


CHAPTER I

Introduction

Until about fifty years ago it was generally believed that for each individual there were as many kinds of what we now call "images" or "centrally aroused sensations" as kinds of sensations; and occasionally, as in St. Augustine's *Confessions* we find introspections to support that belief. It is somewhat remarkable that the "Ideologists" or "Associationists" did not discover the individual differences in imagery, although they had not been trained to make the distinction now made by many psychologists between imagery or sensation and "meaning."

A study of the origin and development of the notion of distinct types of individuals with respect to imagery reveals three more or less independent sources, each leading to separate lines of investigation dealing with different aspects of the problem. The first of these may be traced back at least as far as Fechner's account of the visual imagery of several different individuals, reported about 1860. However, most of the work in this line seems to have been inspired by Galton's report of the difference in clearness of the visual imagery of a fairly large number of individuals. Galton's study, and subsequent studies in this line, have been made exclusively of the images of objects ("concrete" imagery, as distinct from "verbal"). Most of Galton's followers assumed that the individual with indistinct visual imagery must of necessity have clear and distinct imagery of some other kind, although Galton does not appear to have made this blunder.

A second line of investigation, never adequately correlated with the first, also dealt with concrete imagery, but with what Segal calls the "quantitative" aspect, as distinct from the "qualitative" aspect studied by Galton. Instead of dealing with the clearness of voluntarily aroused imagery these studies have been of the *frequency* of the different kinds of imagery that is *non-voluntarily* aroused, although it is non-voluntary only in the sense that no one kind of imagery is specified. Sometimes the subject is prac-

tically required to report imagery, but whatever the instructions, he is likely to "look for" imagery, and the assumption has been that the kind which appears under such conditions is the same as would have been present were he not being "investigated." Among the first of these studies was that of Ribot, reported in 1891, one by Dugas, in 1895, and another by Kraepelin in the same year. Kraepelin asked his subjects to write a list of objects characterized by sight, another of objects characterized by their sound, etc., each list being as long as possible in the five minutes allowed for each list. Differences in the length of the lists were assumed to correspond to differences in the kind of imagery most frequently present. Ribot and Dugas determined the kinds of imagery aroused by prepared lists of words. This method with variations in the method of scoring has been the one most used in investigations in this line, and is referred to by Titchener as the "Secor" method.

A third line of development of the imagery-type notion has dealt with verbal rather than with concrete imagery, and with the quantitative aspect. It grew out of the observations by Charcot about 1880, of aphasias, etc., and with the controversy between Egger and Stricker regarding the relative importance of kinesthetic and auditory imagery in "inner-speech" (*i.e.*, non-visual verbal imagery).

During the "pure-type" period, from 1880 to about 1910, it was generally assumed that the person catalogued as "visual" by one method would be similarly classified by any of the other methods; and also that each individual belongs to some one of several distinct and exclusive types. And because these assumptions were not criticised, any method at all, even chance remarks, were enough for purposes of classification.

About 1910, several investigators began attempts to relate the differences between "imagery" types to other differences between individuals. However, they failed because they did not find the "types." They were surprised to find that the normal individual has some of almost every kind of imagery, and that an individual might be "visual" in one test, "auditory" in another, and something else in a third. These discoveries, and

a more or less general recognition of the fact that for the majority of individuals most of the concrete imagery is visual and most of the verbal auditory-motor, mark the close of the uncritical " pure-type " period.

From this situation, four fairly distinct tendencies made their appearance.

1. One of these tendencies is represented by Thorndike, who denies the existence of clear-cut types, believing rather that we have either but one type, or else as many types as individuals. In other words, he champions the " single-type " as opposed to the " multiple-type " theory. He says: " Instead of a few " pure " types or many " mixed " types, there is one type, mediocrity." He points out that where any phase of any one kind of imagery has been investigated, the distribution curves of the scores are not multimodal, and also that graphs, based on Betts' results, showing the interrelation of the scores for the different kinds of imagery, do not indicate the existence of combination-types.

Thorndike, of course, does not deny the existence of great individual differences in imagery. Even though the existence of some purely visual and some purely non-visual individuals were proven, Thorndike's position would not be affected. The point is that the distribution curves are not multimodal, as demanded by the multiple-type theory, but approximately " normal," in accordance with the single-type theory. He says, " the fact remains that the single type theory arose from exact measurements, while its opposite came from speculative prepossessions." " Lastly," he says, " I may mention the fact that satisfactory proof of the existence of a distribution of human individuals after the fashion demanded by the multiple type theory has never been given in a single case, and that the evidence offered by even the most scientific of the theory's adherents is such as they would certainly consider very weak if they were not already certain that types of some sort there must be."

2. The second tendency is most explicitly shown by Segal, for whom the distribution of types is to be based not on the kind of imagery that is most frequent or most clear in a given individual, but on an inborn tendency to use one kind of imagery more than

any other. The mere fact that seventy-five per cent of a person's imagery is visual is not conclusive evidence for him that the person belongs to the visual type. This same tendency is seen in Pfeiffer who classifies as "kinesthetic" a subject who, out of eighty responses, has 43 visual, 23 auditory, and 14 kinesthetic images. This is done because only for kinesthetic does his score exceed that of the average for the group.

3. A third tendency, pointed out by Dr. Fernald, is "a partial return to the earlier view of distinct types. Though it is agreed that in the last analysis all persons probably belong to mixed types, in the sense that they operate with more than one image form, it is insisted that there are marked differences in emphasis. The terms "visual," "auditory," and "motor" may, therefore, be retained, if they are understood to signify cases where visual, auditory, or motor imagery is predominant."

4. Another tendency at present is to abandon the simple-type notion, and to endeavor to find combination types.[1] This recognizes the fact that on the basis of the actual imaginal content of consciousness all individuals belong to the "mixed"[2] type of the older classification.

Dr. Fernald found it convenient to put her subjects into four groups, each group having more than one kind of imagery. She does not regard this classification as adequate for the classification of larger groups, because the number of her subjects was too small, and too little account was taken of concrete imagery. However, her work covered a wide range of material, and if there were any clear-cut types, she probably would have discovered some of them. In this connection she says: "We have been

[1] The "simple-type" is based on the predominance of a single kind of imagery, the "combination-type" on a combination of different kinds, which may be regarded as typical for a group of individuals. On either basis we might have either "pure" or "mixed" types, although by "pure type" we ordinarily mean "pure simple-type." There is a tendency to confuse types of imagery with types of men as regards imagery, which must be avoided.

[2] There is considerable ambiguity in the term "mixed" type. For most writers it means simply that a person may have one kind of imagery in one situation, and another in another. Segal objects to this, saying that in this case the person belongs to more than one type (whatever that may mean)! For him the mixed type is characterized by the simultaneous presence of more than one kind of image.

forced to conclude, therefore, that the individual differences in imagery are too complex to be stated adequately in terms of differences in 'types' unless this 'type' is carefully explained in each individual case." As to the advantage of some classification, she says that "In spite of our belief that an individual's type can be adequately indicated only by an extended statement, we recognize that it is desirable to group subjects in accordance with certain of their more striking characteristics." However, though possibly desirable, it is very often seriously misleading.

Inter- and Intra-Individual Comparisons. Another source of confusion is to be found in the fact that some writers have an intra-individual comparison in mind when using the term "type," while others have an inter-individual comparison in mind. On the first basis (intra-individual) a person is classified according to the kind of imagery which for him is the most clear or most frequent; on the second (inter-individual) he is classified with reference to the group average for each kind of imagery. This second method is used by Segal, Pfeiffer, and others. Pfeiffer, in the case already referred to, classed as "pure kinesthetic" an individual with 54 per cent of visual imagery, 29 per cent of auditory, and only 18 per cent of kinesthetic, because only in kinesthetic imagery did he score higher than the group average. Those who use the first basis would classify this individual as "visual" or "mixed."

The Problem

The main purpose of this investigation was to bring together the different lines of investigation dealing with the different aspects of imagery, in an attempt to determine more fully the nature and extent of individual differences in imagery. Each of the three lines of investigation we have discussed is represented by at least one of the seven tests to be described. Tests 1, 2, and 3 deal with the qualitative aspect of concrete imagery, Test 4 with the quantitative[3] aspect of concrete imagery, Tests 5, 6, and 7

[3] Following Segal's terminology, the "dominance" tests (Tests 4 and 5) are classed as "quantitative," although these "dominance" tests measure, not mere frequency, but more the degree to which attention is dominated by each

with the quantitative aspect of verbal imagery. Each of these tests will be described in order in the following chapters. If time had permitted, the series of tests would have been extended to cover also the qualitative aspect of verbal imagery.

Schedule and Subjects

Seven hours of each subject's time were available, and these were divided into four periods. The tests or parts of tests given at each of these periods are outlined below. It was frequently necessary to depart somewhat from this schedule. With the last group of forty-four subjects more of the work was done in small groups in the laboratory.

Period I. Two hours, individual tests.
- Test 4, 25 words, auditory presentation.
- Test 6, U-L, backward repetition.
- Test 5, part c, letter squares.
- Test 5, part e, multiplication.
- Test 5, part d, recall of poetry.

Period II. Work by student, alone.
- Test 4, 25 words, visual presentation.
- Test 1, clearness.

Period III. Two hours, individual tests.
- Test 2, visualization.
- Test 4, 20 sentences, auditory presentation.
- Test 5, part g, silent reading.
- Test 5, part h, inner-speech while writing.
- Test 5, part f, verbal imagery in "thought."

Period IV. Two hours, small groups.
- Test 5, part b, memory, letters and digits.
- Test 4, 25 words and 20 sentences, visual presentation.

kind of imagery. It may be noted that what some writers have presented as "frequency" scores involve dominance in one way or another. Pfeiffer recorded but one kind of imagery for each response, for the reason that when more than one kind are present there is always one "welche also in der Reihe der Assoziation, die sich an dass reizwort anschloss, die grosste Intensitat besass."

Strictly speaking, we can hardly speak properly of the "quantity" of imagery. The terms "frequency" and "dominance" are more specific.

With few exceptions an interval of one week separated the first and third, and also the third and fourth periods. This procedure tends to diminish the influence of the first few responses of the dominance tests upon the remainder of the series. If the first few responses are of any one kind, the subject may begin to expect more of that kind, and this partiality of attitude would seriously decrease the validity of the results. Another reason for dividing the time devoted to a dominance test is the possibility that the factors controlling the dominance of the different kinds of imagery may change from day to day. Although this change, if any, is likely to be relatively small, it is well to play safe. If there is such a change, the intervals obviously allow one to secure more valid results.

One hundred twelve subjects, all of whom were beginning students in psychology, were tested. They belonged to four different classes (four successive semesters) and are grouped accordingly. Subjects 1 to 25 belong in Group A, subjects 26 to 40 in Group B, subjects 41 to 68 in Group C, subjects 69 to 112 in Group D. Groups A and C were laboratory students who had been in the laboratory from three months to one school year. Groups B and D had had no laboratory experience. All of the data were obtained during the school years 1916–1917 and 1917–1918. In the tables in the appendix the letter after the subject's number refers to the sex.

CHAPTER II

Test 1. Clearness of Concrete Imagery

This test is a modification of the Galton questionnaire. It differs from the original not only in the material used, but also in the method of scoring, which involves a partial application of the order-of-merit method. This method of scoring is explained below in the instructions to the subject and in the discussion which follows.

Instructions

"The purpose of this test is to determine the clearness of the voluntarily aroused imagery of the different kinds. It is to see how clearly you can imagine experiences in the different sense-departments."

"In each case you will find an abbreviation of the kind of image (imagined sensation) you are to get of that particular object. Following the designation of the kind of image is the name of the thing you are to try to image. For examples: (1) means, 'How clearly can you imagine the sound of a violin?' (11) means, 'How distinctly can you imagine the visual appearance of a violin?' (48) means, 'How clearly can you imagine the taste of an orange?'"

"Before assigning any values to any of the images, go carefully through the whole list and select five (of any kind or of different kinds) which you can image as clearly as any in the list. Give them a value of 10 and record this in the space immediately after the number and before the abbreviation of the kind of image. Then go back to the beginning of the list, and using those selected as directed as the standard, score the clearness of the voluntarily aroused image in each case. The scores will therefore range from 0 to 10; 0 if you cannot get the image called for at all, 10 if as clear as those selected as the standard."

"Always be sure that you really get the kind of image called for. Do not confuse the act of smelling a rose with olfactory image of the rose. Nor should you be influenced by the fact that you would recognize the odor of a rose if it were really present. Grade your ability to imagine the odor of the rose."

"Again, do not confuse a visual image of a moving object with a kinesthetic image. These and other mistakes of a similar nature are frequently made by the careless."

The material for all the tests appears in the appendix.

The older method of scoring was to compare the clearness of each image with the clearness of perception. This was rejected for two reasons. In the first place students frequently ask "How

can I compare an image with a percept when the object is not here to be perceived?" And there is a point to the question. The second reason lies in the tendency for some students to overrate the clearness of all their images. Betts found that when subjects repeat a similar test the scores are generally lower the second time. The method I have used eliminates the first difficulty entirely, and at least reduces the tendency to overrate.

The greatest obstacle to the use of any such test is the introspective difficulty, which is greater than in most of the other tests. A considerable number of my subjects declared themselves unable to perform the test satisfactorily. Where these did try, the scores ordinarily were about the same for each kind of imagery. Ordinarily all of the imagery of such subjects is vague and indistinct.

After all of the last group of forty-four subjects had completed the test and had handed in their papers, they were asked to repeat the test. This occurred from one to eight weeks after the first trial, and was unexpected by the subjects. This was done to test the reliability of this rather difficult test. There was no general tendency for the scores to be higher or lower in the second trial.

Results

The scores for the visual, auditory and kinesthetic imagery of each subject are given in Table A, columns 2, 3 and 4. Results were obtained for but 87 subjects. In some cases the subject claimed he was unable satisfactorily to perform the test on account of the introspective difficulty. This occurred most frequently with the untrained subjects of groups B and D. Several of group D left school rather suddenly to enter the army or navy, and as this test was performed in the subject's room it was frequently the last one finished.[1]

Distribution of Ranks and Rank-Orders. Table A (in the Appendix) shows that visual is first in 90 per cent of the cases, auditory first in 5 per cent, and kinesthetic in 5 per cent. In 76

[1] When all the other tests had been completed, the results for those are given. When only a part of the other tests had been completed, no record was kept of what had been done.

per cent of those cases where visual ranks first, auditory ranks second; in 24 per cent kinesthetic ranks second. In every case where auditory ranks first, visual is a close second. In the five cases where kinesthetic ranks first, visual is second in three and auditory in two.

Averages. The averages of the scores for each kind of imagery are: visual 85.3; auditory, 68.6; kinesthetic, 60.4. The median score for each is slightly higher.

The differences between these average scores are not so large as the distribution of ranks would indicate. This relation between distribution of ranks is, however, in line with the possible assumption that in early childhood, the capacity for imagery in the different fields is equal, and tends to remain so, and that the superiority of the visual imagery in adults is due to its being more frequently used—perhaps because attention is dominated more by visual than by auditory experiences, and because recall tends to be in terms of the more attended-to elements of the original experience.

In this connection it should be noted that the variability of scores for each kind of imagery is lower in this than in any of the other tests. Also that both the standard deviation and the coefficient of variability are smaller for visual than for auditory or kinesthetic imagery.

Frequency Curves. The frequency curve (see Appendix) for visual is a " J " curve. Those for auditory and kinesthetic are more nearly " normal," but both are skewed to the right, the auditory more so than the kinesthetic. The only indication of bi-modality is seen in the curve for kinesthetic. This bi-modality is due to the fact that in all the tests, objective as well as introspective, Group D averages higher in auditory and kinesthetic than the first two groups, although the difference is often small compared to the probable error. These differences may be due to chance in sampling, or to some influence of class discussions of imagery, which the first two groups had had, but the last two had not. The experimenter had no part in any of these discussions, so had no control over that possible factor.

Intra-Test Correlations. These correlations are:

Visual and auditory	.46, p.e., .05
Visual and kinesthetic	—.01, p.e., .07
Auditory and kinesthetic	.30, p.e., .06

There is a fairly high correlation between the clearness of visual and auditory imagery, none between visual and kinesthetic, and some between auditory and kinesthetic. There are some subjects (S 26m, for example) whose visual imagery is relatively clear but whose auditory is relatively indistinct. But there was no subject with clear auditory imagery who did not also have clear visual imagery, nor any with weak visual and strong auditory imagery. With these subjects clear auditory has always been associated with clear visual imagery, and clear visual is generally, but not always, associated with clear auditory. These statements are based on the results not only of this but also of other tests.

There seems to be no general correlation between the clearness of visual and of kinesthetic imagery, yet ordinarily those with good visual imagery are able to summon clear kinesthetic imagery; although in ordinary circumstances they may never notice the kinesthetic, which, if present at all, is crowded out of attention by the visual and the auditory. The zero coefficient of correlation is probably due to the fact that when visual imagery is very indistinct the kinesthetic becomes more noticeable,[2] though it may not be absolutely any more distinct than for those subjects with clear distinct visual imagery. If good visual and auditory imagery are available they ordinarily dominate attention; when they are not available, or are very poor in quality, the kinesthetic, which may always be present, becomes dominant. In particular cases where the subjects get meaning but no noticeable imagery, all imaginal factors may be regarded as having sunk below the threshold, when it ceases to be imagery, although the same neurological processes may be active. Such cases of apparently "imageless thought" are, however, rare in a test which involves the voluntary arousal of imagery.

Clearness in auditory imagery seems to go with clearness in

[2] Egger believes this to be true.

visual, and to some extent with kinesthetic imagery. Clearness in kinesthetic imagery stands more nearly alone, being correlated to a certain extent with the auditory, but not at all with the visual.

These correlations are affected somewhat by the tendency of some subjects to grade all their imagery higher than other subjects, although the clearness of the imagery of the different subjects may be the same; and this tendency, if strong, would result in spurious correlations. Although this tendency was doubtless present, the correlation (—0.01) between visual and kinesthetic indicates that its influence was limited. The correlations are reduced by the presence of those subjects whose visual imagery is vague and indistinct, although it ranks far above their auditory and kinesthetic imagery. The experimenter in working with the subjects may get a much more accurate impression of the absolute clearness of the subject's imagery than is revealed by these figures. It must be kept in mind that this test deals only with the ability ordinarily to call up imagery of a specified kind in each case.

Individual Differences: Types. Great individual differences are revealed by the ranges of the scores, ranges which are about equal for the auditory and kinesthetic fields. The highest scores for the visual are those of subjects 10m, 22m, and 26m, although the latter has a fairly clear kinesthetic imagery. Subject 82m represents the other extreme regarding visual imagery. Subjects 11w, 12m, 13w, and 69w graded auditory higher than visual or kinesthetic, although all but the last graded visual a close second. She, however, has clearer visual imagery than the average of the group. Subject 25m has very clear visual imagery, although his results in this test do not indicate it. It furnishes one of the cases where the results suffer from the tendency of some to grade closer than others. He is an illustrator and cartoonist, and says he pictures every detail in his mind before sitting down to draw his pictures. Subjects 41, 42, 45, 56, 82, graded kinesthetic higher than any other kind, although only the last two show any marked superiority. Subject 82 is the nearest approach to a "pure kinesthetic type." It should be said that this is one of the few subjects who had made up his mind as to his own "type" before

taking the series of tests. In his university work this student is hampered by an almost constant but ineffectual attempt to visualize. He started out to be an engineer, but says he failed or nearly failed in so many of the courses through inability to visualize that he changed to botany, where he does fairly well.

Sex Differences. The average scores of men and of women for each kind of imagery were as follows:

Men.....	Vis. 93.3	Aud. 73.8	Kin. 60.6
Women....	Vis. 75.6	Aud. 62.3	Kin. 56.5

It is evident either that the imagery of men is relatively superior to that of women, or that the women were more conservative in grading the images and somewhat more careful in their work.

Reliability of the Test. The reliability of this test is largely dependent on the clearness of the imagery of the subject. As stated above, a great many of the subjects in Groups B and D declared themselves unable to grade the images with any satisfactory degree of accuracy. In two cases in Group D the results were thrown out because there were radical differences in the results of the two trials. Those in Groups A and C, who had had some experience in the laboratory, did not have so much difficulty with the test, although most of them stated that it was the hardest of the series. Some of these were afterward asked to grade the images by comparison with the clearness of perception to determine if the latter method would be any easier. Any difference seemed to be in favor of the first method used.

The fact that Group D repeated this test enables us to get a coefficient of reliability for this untrained group. The coefficients of reliability thus obtained are, for visual, .85; for auditory, .72; and for kinesthetic, .79. These coefficients indicate considerable agreement between the results of the two trials. These two trials were separated by an interval of from one to eight weeks. On the whole the test is useful for trained subjects with open minds, and for others if they are asked to report their ability, in their own estimation, to perform the test satisfactorily. Each subject should be asked candidly to state his opinion of the value of the results of the test in his own case.

Summary

1. This test is patterned after that of Galton, with a revision of the material, and a change in the method of scoring.

2. Visual imagery ranks highest in clearness in 90 per cent of the 87 cases, auditory in 5 per cent, and kinesthetic in 5 per cent.

3. There is a positive correlation between the clearness of visual and of auditory imagery. Every subject with clear auditory imagery has clear visual imagery. No subject with poor visual imagery has clear auditory imagery. Some with clear visual imagery have poor auditory. There is no correlation between the clearness of visual and of kinesthetic imagery, and but a small positive correlation between auditory and kinesthetic. These statements, of course, refer to concrete imagery only.

4. The results show great individual differences, but there is little if any evidence for types.

5. The average scores for each kind of imagery are higher for men than for women. This may indicate better imagery for the men, but may be the result of more careful and conservative grading by the women.

6. The coefficients of reliability for visual, auditory and kinesthetic are .85, .72, .79, respectively.

CHAPTER III

Test 2. Visualization

The instructions, which were read by the subject and supplemented by verbal explanation, were as follows:

"After the experimenter says 'ready' you will turn over the first card, read carefully, and give the answer called for as soon as you can. If the answer you give is wrong you will be so informed, and you will continue to work until you have given the correct answer, or until you have worked five minutes. If you have not succeeded in five minutes the experimenter will stop you and at the signal 'next' you will turn over the next card, etc. The work is all to be done 'mentally' and you are not to use the card or any object in the room in any way as an aid, nor are you allowed to trace the figures on the table with your finger. Otherwise you may move your hands about as you wish. A record will be kept not only of the time required to give the correct answer, but also of the number of wrong answers given. They are equally important."

The problems are given in Appendix A. It will be noticed that this series includes the "three-inch-cube" problem used by Betts and others. The chief objection to these cube problems lies in the fact that only from a third to a half of the subjects remember the number of corners, edges, and sides to a cube. I now believe that it would be better to give this information to each subject at the start, thus placing all on an equal basis. The other problems were devised to eliminate this difficulty as far as possible, as well as to eliminate the factor of calculation from a partial visualization. With problem 7a, for example, about half the subjects, by visualization, count the parts of some one of the three rectangles and multiply by three. In any case this answer will be wrong, and the other parts must also be visualized.

Each part was considered a separate problem. These were typewritten on narrow strips of paper, long enough to prevent their being used as sensory aids. The slips were numbered on the back and placed in a pile, face downward, on the table. The subject faced a bare plastered wall across the table.

In giving this test to Group A, only the first answer was considered, this being recorded as right or wrong, with the time.

This method was given up, and the results discarded, for two reasons. First, there is the tendency of some subjects to save time by guessing at the answer, and second, the tendency to visualize a part of the figure and then to calculate the answer from the results of the partial visualization.

The score finally adopted is the number of seconds necessary to give correct answers. If any problem remained unsolved at the end of five minutes, it was counted as a failure and 400 seconds entered in the time column. This method of treating failures is of course arbitrary, yet if each failure is counted as 300 seconds it changes the ranking of the subjects but very little. This is due to the fact that ordinarily the subject succeeds, if at all, in the first two or three minutes. The correlation between the scores thus obtained and those which would result from allowing a work period of four minutes and counting failures as 300 seconds is .98 (Pearson products-moments method). If one wished to give each problem equal weight, the scores for each problem could be given as deviations in terms of the probable error.

It will occasionally be asserted that the problems can be solved without visualization, and it is probably true that a congenitally blind person could solve them. An adequate discussion of this question would bring in the whole psychology of space, yet I see no reason for doubting that for normal seeing subjects the visual cortex is involved in the solution of these problems. Although it is by no means established that this would necessarily result in noticeable visual imagery. In some connections it has been shown that imagery becomes less and less prominent with increased efficiency. This of course may mean that there is in such cases a gradual elimination of the activity of the visual cortex, or that the contribution of these areas is not always made manifest by the presence of visual imagery. At present there is some doubt in the writer's mind as to the propriety of calling this a " visualization " test at all, if by visualization we are to mean the conscious dependence of visual imagery. Yet this doubt is nothing stronger than suspended judgment.

On the other hand, subjects who failed with any problem *always* attributed their failure to an inability to picture the figure

in their mind, or to hold the image long enough to count the parts, and this without any suggestions from the experimenter. Experience in giving the test seemed to confirm its value as a test of visualization, yet it also showed that on the side of imagery alone other factors than that of clearness must be considered.

Results

Results for this test are reported for Groups C and D only, as it was found that the method of obtaining scores used with Group A gave results of but little value. The necessary revision had not been made when the subjects for Group B were being tested.

Scores. The average time required to complete the set of problems was 1,218 seconds, the median 963, with a S.D. of 774, and a V. of 61. There is a very wide range—from 303 to 3,548. The average time for Group D is nearly 200 seconds better than for Group C. The actions of a very few of the subjects of Group D during the test caused me to suspect that they had been coached on some of the problems, although there was no way to be sure of this, and their scores were ordinarily in accord with the results of other tests. All of the results of all the tests for one subject were discarded, as it was certain he had cheated.

Frequency Curve (see Appendix). This is greatly skewed toward the right (better scores). Two-thirds of the cases are better than the average for the group, and rather closely grouped. The greatest variations from the central tendency are found in the poorer visualizers, even when failures are eliminated. It is with these that the test has its greatest value. That the form of the curve is not the result of the treatment of failures is shown by the curve for those scores which do not include failures.

Individual Differences: Types. The range of scores, 303 to 3,548 seconds, indicates the extent of individual differences revealed by this test. Only one of the best five is making any specialty of mathematics. The best score (S 65m) was made by a student specializing in economics. S 87m, an artist and illustrator, made a very high score. S 69w, third in rank, is

specializing in mathematics. S 82m, who left engineering for botany because (he says) of his inability to visualize, made a score of 2,460. The better students in advanced geometry, trigonometry and kindred subjects would probably make better scores in this test, possibly not so much on account of practice as on the factor of elimination, and the attraction of students to those lines of work for which they are best fitted; *i.e.,* which are easier for them, or in which they can do better than the average.

Sex Differences. The average scores for men is 1,152.3; for women, 1,320. This difference is not large enough to warrant any definite conclusions. Seven of the nine best scores (below 500) were made by men. Six of the eleven scores above 2,000 were made by men, five by women. There were 44 men and 28 women in the two groups taking this test.

Reliability of the Test. Various factors affecting the scores of this test have already been discussed. Scores are influenced by at least three factors—the clearness, stability, and complexity of the image. Several subjects reported, "I can see it plainly enough, but it gets away before I can get all the parts counted." Some subjects succeeded very well with the less complex figures, but failed with the more complex ones. There is a certain limit in the complexity of the images possible for a given subject, which differs greatly for different individuals. Beyond this limit the figure must be imaged in parts.

That the operation of the aggregate of the above factors is fairly constant is indicated by the fact that there is a correlation of .72, p.e., .05, between the results of the first twelve and the last four problems given to Group D.

Summary

1. The scores obtained by this test are based on the time required to solve a series of problems, which include the "three-inch-cube" test, and others of a more or less similar nature.

2. This test reveals great individual differences. The scores range from 303 to 3,548 seconds.

3. There is no evidence of the existence of types.

4. There are no clearly marked sex differences.

5. The correlation between the first twelve and the last four problems is .72. The scores are affected by various nonvisual factors, and also by different phases or aspects of visual imagery—clearness, vividness, stability, and the limit of complexity.

CHAPTER IV

Test 3. Clearness: Fluctuation

During the preliminary work the subjects were asked to see how long they could hold a visual image of a circle. This is a splendid method for quickly gaining an insight into the clearness and stability of the subject's visual imagery, but unfortunately it does not give numerical scores with regard to the clearness. Some subjects describe their image as something clear, definite, distinct, and are never in doubt as to whether the image is present or not. These subjects nearly always report a regular rhythm of fluctuation, which may take any one of a variety of forms, but they can describe definitely all the changes in their images. Others can never be sure whether they have an image at all, and report that their "mind wanders" and that they can never tell when there is an image and when they are merely "thinking about" the circle. In these cases it is obvious that the image, if present, is very vague, for there seems to be no noticeable difference between image and no-image.

I decided therefore to include this test in the series of experiments, and to give to each subject one of five grades with regard to clearness. The series of objects to be visualized was: circle, rose, triangle, flag, square, chrysanthemum. The same method was tried with sounds, but with unsatisfactory results.

The instructions were: "I want you to see if you can get and hold a visual image of a circle, first for thirty seconds, and later for sixty. I will tell when the time is up."

Immediately after the trial the subject was asked to "describe in detail the appearance and behavior of the image."

Results

As stated above, this test was included in the series to give the experimenter an opportunity to judge the clearness of the subject's visual imagery, without having to wait for the tabulation of

the results of the other test. The test brought out very marked individual differences in other aspects of the imagery involved, which are also reported.

Five grades in clearness were given, A, B, C, D, and E, A being the highest and E the lowest. The grade for each subject is given in Appendix II, Table B. The limited time available made it impossible to give this test to Group D.

Scores. Of 68 subjects, 19 were graded A, 20 B, 23 C, 5 D, and 1 E. The last subject, 17m, represented a puzzling problem. At times I was inclined to regard him as "imageless," at other times as intellectually deficient.

Sex Differences. There were more men at both extremes of the scale: 32.6 per cent of the men and 20 per cent of the women were graded A; 11.6 per cent of the men and 4 per cent of the women were graded D or E. The one subject graded E was a man. The distribution of scores is more concentrated, and more nearly "normal" for the women than for the men.

Images of Memory and of Imagination

The introspective reports tend to place each of the images into one or the other of two main groups. This division is in accord with the distinction made by Perky[1] and by Titchener between images of memory and images of imagination. The first group contains all the images of memory. The images of imagination are divided into three classes.

1. Memory images occur most frequently for the rose, chrysanthemum, and flag. From two-thirds to three-fourths of the

[1] The results reported by Martin, Ogden, and Clark disagree at many points with Perky's results. This is partly due to difference in procedure. I believe also that the introspective task set by Martin, Ogden, and Clark to be too difficult for the great majority of subjects. Many subjects never report images of imagination. or at least never report anything which might suggest the presence of a retinal factor. Some subjects, with effort, can summon an image which *seems* to have a retinal basis, *e.g.*, "a circle of phosphorescent light," although this may not ordinarily be present. Although I did not have the discussion arising from Perky's work in mind when I began to use the test described in this chapter, yet I believe that the method used is one of the best for bringing out the distinction between the two kinds of images.

images of these objects belonged to this class. From one-third to one-half of the images of the geometrical figures were in this group.

The subject thinks of some previously experienced object, with recognition and with time and place localization. Instead of reporting some definite rhythmical change, he ordinarily reports that "the mind wanders," generally to some associated object in the image. With the images of imagination there may be a certain amount of this "wandering" without losing the image, just as there might be in a dark room when we are watching a rhythmically appearing and disappearing light. Sometimes, with images in this class, there may be a succession of images of the object, each in a different setting. The memory *image* is more likely to be vague, indistinct, and fleeting, although the *meaning*, familiarity, localization, etc., may be quite definite. A lack of regular and rhythmical change in the image itself, with a tendency for the mind "to wander," was generally considered sufficient evidence that an image belonged to this class, although familiarity and time and place localization might also be regarded as criteria.

The image of memory may be contrasted with the image of imagination with regard to its tendency to drop almost altogether from consciousness, leaving little if anything but the meaning. A subject may report that he was "thinking about the circle most of the time" without being able to tell when there was an image and when there was not. With memory images attention seems to be more to the meaning than to the image itself. The image of imagination, generally lacking any time or place localization, or familiarity, seems more able to hold the attention to itself. At times an image of imagination suddenly becomes a memory image. For example, one subject reported for the circle: "I succeeded pretty well, although the image would try to get away once in a while, until I thought of Professor X drawing one on the board this morning. Then my mind kept running off to the lecturer and to what he said, and to other things connected with the lecture and the lecture room, which made it hard to tell when I had the image and when I did not."

2. This class is composed almost entirely of "images of imag-

ination." The image gradually fades out, and later comes back. The following is typical:

"I saw a black circle on the wall (of the room). It gradually faded out, beginning at the bottom. Effort brought it back only to have it fade out again. There was a constant tendency for the image to move upward, and it required effort to keep it down" (S 50m).

Frequently there seemed to be a display of retinal light. S 56w reported: "I saw a sort of halo of phosphorescent light that gradually faded out, and later came back again.[2] Kinesthetic images(?) of following the outline of the circle with the eyes seemed to help in getting it back and in holding it there."

3. This class also includes images of imagination. It differs from the second in that the image instead of fading out tends to change, with about the same temporal rhythm. S. 44m, for example, reported:

"I would have the triangle firmly fixed when it would begin to flatten out until I had only a straight line, which might disappear altogether. I could get it back but it would persist in doing the same thing again." Sometimes one side would disappear, then another, although the whole was seldom gone at any one time. This tendency appeared in subjects 12, 16, 3, 5, 13, 11, 1, 38, 28, 62, 50, 60, 58.

4. A third kind of response for images of imagination is sometimes found. For example:

"I was thinking of a circle and saw it as a kind of circle of light. Soon it began to be blotted out by a square, but I finally got it back only to have it blotted out later by a triangle, etc." (S. 43). Nearly all of the responses of subjects 24 and 37 belong to this class.

Eye-strain and what seem to the subjects to be retinal lights may

[2] Fluctuation of images has frequently been reported. This may be taken as evidence against the peripheral theory of the fluctuation of attention unless the image has a peripheral basis, which is at least possible in the case of visual imagery. Titchener suggests that this is true for the stable images of imagination. In this connection the infrequency of auditory "images of imagination" may be significant. So, also, the frequently reported eye-strain accompanying visual images of imagination.

be found in each of the last three classes. It was never reported in connection with "memory images," *i.e.,* the first class in the above classification.

In addition to the longer periods of fluctuation, which ranged from 4 to 24 seconds, there was for a few subjects a very interesting secondary fluctuation of less than a second. This was found in but five cases, Subjects 4, 11, 26, 31, and one of the twenty used for the preliminary investigations. It was most definite in the last, with whom considerable extra work was done along this line. These investigations with this subject were ended by an operation for appendicitis. His health had been poor for some time. He reported:

"I can see the rose at the end of a long stem. It seems to be shaking or quivering all the time it is present. It always gets away from me for a while but I can always get it back."

"I can see the 'mum' at the end of a long stem, no background or surroundings. As I look at it the petals begin to fall one by one, very rapidly, until they are all gone, and there is nothing left but the stem. When I get it back the process is repeated."

"The circle, just out in space, is always turning rapidly in spite of all I can do to hold it still. I try to hold it in place but it finally gets away from me and rolls off to the left. When I get it back it does the same thing again."

The longer rhythm in each case was about seven seconds, the shorter about six-tenths of a second.[3]

Approximately three-fourths of the subjects who reported "images of imagination" seemed to support the visual image by some kinesthetic image or sensation. Some subjects could get a visual image only after tracing the figure in the air. With some there was a movement of the eyes as though they were following the outline of the figure with the eyes. One subject reported that she "could see the image" only by following the outline of it with her eyes and at any one time could see only the part of the image which she was "looking at at the time." In many cases the image was supported by a verbal repetition (inner-speech),

[3] See Pillsbury's *Attention* and Shepard and Billing's article for discussion of the two rhythms of attention.

ordinarily of the name of the object. Some verbal imagery was present in the majority of cases.

One subject showed a rather constant tendency to have a projected image of himself. For the circle he reported: "I saw myself looking at the circle on the board. Then I saw and at the same time felt myself rubbing the circle off the board, and then had to get it back again."

The above introspection also reveals an interesting tendency shown by some subjects to have some explanation, as it were, of the disappearance of the image. This tendency is especially prominent in the reports of subjects 60w, 62m, and 67m. For example: "A little elf inside me seems to keep pushing it (triangle) away" (67w). "I saw a circle on the wall, but all at once a woman seemed to be brushing it out" (62m).

Sometimes the change in the image occurs when the subject "gets tired looking at it." One subject reported "an increasing sense of effort until the image disappears."

It was seldom difficult to determine whether an image should be classed as an image of memory or of imagination. It was at times not so easy to decide to which of the three classes of images of imagination any given image might belong, and I am not ready to stress either the importance or accuracy of this latter division. If in the beginning the purpose of the test had been to bring out these distinctions more significant data might have been obtained. As to the distinction between the images of memory and imagination, if anyone will give this test individually to a large number of subjects he will be able in time to detect, in a great majority of cases, the kind of image that will be reported from the outward behavior of the subject. Of course nothing was said to these subjects about different classes of images. The experimenter did the classifying.

A longer list of objects to be imaged might have made it possible to determine how far there may be individual differences in the percentage of the two main kinds of images and of the different kinds of the images of imagination.

Summary

1. The subjects were asked to try to hold a visual image as constantly as possible for thirty and sixty seconds, and to report in detail regarding the behavior of the image. The experimenter's judgment of the clearness of the subject's images was based on this introspective report, or on the subject's inability to give any report at all.

2. The responses may readily be classified as memory images or images of imagination, as described by Titchener.

3. A longer and shorter period of fluctuation of the same image was found in four of the 68 subjects, and in one in the preliminary group of 20 subjects.

4. In the majority of cases the visual image was supported by some kinesthetic image or sensation, and by inner-speech.

5. In a few cases there was a visual self-projection.

6. Sometimes there was some dream-like explanation of the disappearance of the image.

7. Eye-strain was sometimes reported in connection with the images of imagination.

8. What seemed to be retinal light was often present as the basis of the images of imagination. This may account for the greater stability of these images.

9. Colored imagery was reported by a considerable number of subjects.

CHAPTER V

Test IV. Dominance of Concrete Imagery

With the exception of the method of scoring this is practically the same as that designated by Titchener as the Secor Method. Somewhat similar procedures have been followed by Feuchtwanger, Pfeiffer, and others. The instructions for oral presentation were as follows:

"During this test please assume as much as possible the attitude of a passive spectator to what goes on in your mind. I will read a word from this list, and I want you to tell me just what comes into your mind as you think of the object. If it be the way it looks, answer 'visual'; if some sound, answer 'auditory' or 'sound'; if some muscular activity on your own part answer 'motor'; if it be a taste or smell, or heat or cold, answer accordingly. Don't try to get any particular kind of response, but let come what may. Please try to avoid the expression 'I thought of,' or 'I thought about.'"

Words from a practice list were then given until the subject answered that more than one kind were present, when the following was asked:

"Which of the two (or three) seemed to be more dominant, that is, which is more in the center of consciousness, and which more in the background?" After the answer had been given the subject was told that "I want to know not only which is the more dominant but how much so. Out of a total of seven points how many would you give to one and how many to the other?"

It will be seen that the instructions are to "think of the object," which tends to eliminate verbal imagery.

The use of the word "image" should be avoided in the instructions to subjects not familiar with the psychological use of the term.

Material. The lists of 75 words and 40 sentences are given in Appendix A.

The selection of the words and sentences was guided by two principles. They should refer to experiences or objects common to all the individuals to be examined, and to experiences involving more than one sense-department. The former needs no discussion. As to the latter it might seem at first that, if a list is to be perfect, each word or sentence should refer to experiences involving equally all the senses, or, as this is not possible, that all the senses will be equally represented in the list.

But the matter is not so simple. There is a tendency for the memory to be in the same terms as the original experiences, and in our every day life we probably attend more to the presentation of some senses than to those of others. These facts must be reckoned with if we are to determine the extent to which each of the different kinds of imagery is actually present. The purpose of this test was to determine the relative dominance of each kind of imagery in the non-verbal content of the subject's imaginal consciousness, and the words and sentences were chosen accordingly.

The list of words was selected in this way: A three-minute, free, continuous association test was given to an independent group of over 100 subjects and from the papers thus secured a list of 175 words was chosen. Those words were selected which appeared most frequently and which are " adequate stimuli " for more than one kind of imagery. This list was then used for individual testing with 19 subjects (used only in preliminary work), to determine the kind or kinds of imagery aroused by each word. This group proved to be satisfactorily heterogeneous. Each word in the list that had aroused only one kind of imagery was eliminated. Each of the words thus eliminated were those which had aroused nothing but visual imagery. A few of the words seemed to offer great introspective difficulty, and as very little new light could be thrown on the question of imageless thought by leaving them in the list, these words were also eliminated. As a result the list was reduced to 75 words, as given in the Appendix.

The 50 phrases and sentences were selected from a trial list of 75, from which 25 were eliminated in the same manner as that by which the list of words was reduced.

It will be noted under " Schedule " (Chapter I) that only 25 words were given at any one time. This was done, first, to avoid the possibility that for individuals some kind of imagery may be favored more on one day than on another, and, secondly, because in the preliminary investigation it was noticed that if several successive words had called out the same kind of response the subject often seemed to get into a rut, which might give misleading results. When in any one list given orally the experimenter

suspected such a tendency, some other word farther down in the list which would tend most strongly to call up another kind of imagery would be read.

Although Feuchtwanger claims that the method of presentation makes little difference in the kind of imagery aroused, it seemed but safe to present some of the words orally, and some visually, 25 words and 25 sentences were given verbally and 50 words and 25 sentences visually. For the visual presentation of both words and sentences a cover sheet was used so the words or sentences would be presented singly. The method of scoring was the same.

Scoring. As explained in the instructions to the subject, if more than one kind of imagery is excited by a word, the relative dominance of the different kinds is expressed by a distribution of points. Later the points for each kind of imagery were totaled and reduced to percentages, based upon the total number of points, which is always seven times the number of words or sentences. Percentages were computed separately for words and for sentences, which were then averaged. This puts the 50 sentences on a par with the 75 words.

During the preliminary work the distribution of points was at first on a basis of 10. But this made it too easy for the subject to say " about half and half," when as a matter of fact one is more or less dominant. The number 5 was then tried, but difficulty arose when there were more than two kinds of imagery. Seven seemed to work best and was finally chosen.

Feuchtwanger merely recorded the kind or kinds of imagery excited by each word, counted the total number of visual, auditory, and kinesthetic reactions, and then reduced these numbers to percentages of the total number of reactions. This procedure scores an image which appears alone the same as another which appears in conjunction with several others, and which may occupy a position in the extreme outer fringe of consciousness. This measures frequency alone, and makes it possible for an individual to give equal scores to visual and auditory imagery, even though the auditory imagery may be so fleeting, so indistinct, and so far

removed from the center of attention that the subject hesitates in mentioning it at all.

It has also been suggested that we might reduce the total number of appearances of each kind of image to a percentage of the number of words in the list. This procedure gives results in many cases quite different from the results obtained by Feuchtwanger's method. For example, if both visual and auditory images were aroused by each word, and no other kinds were present, by Feuchtwanger's method each would score 50, but on the other method each would score 100. Now if there were a third individual who had nothing but visual imagery his score would be 100 on each basis, ranking no higher than an individual who has as much auditory as visual imagery. However, if it is mere frequency that we want to measure, the two ought to have the same score in visual imagery.

Pfeiffer recorded but one kind of imagery for each word, that kind being the one " welche den Kindern als die bedeutsamste erschein." The score for each kind of imagery is the number of such responses, although in some places he reduced this to a percentage of the number of words. Thus his scores represent, not simple frequency, but the frequency of dominant images. The objection to his method is that only one kind of imagery is recorded, although some other may be present and almost equal. A subject with purely visual reactions for every word would rank the same in both visual and auditory imagery as another for whom auditory imagery was always present with the visual, but occupying a secondary place.

Titchener's method of scoring is to allow one point for each image which stands alone, one-half for each when two appear in conjunction. The results thus obtained represent more accurately the state of affairs in everyday life than those obtained by either Pfeiffer's or Feuchtwanger's method. In basing the results on a " distribution of seven points " for each word, I have simply gone a step farther than Titchener, taking into account the relative dominance in each case.

Results

The scores for the visual, auditory, and kinesthetic imagery of each subject are given in Appendix II, Table A. The scores for the other sense-departments are not given because ordinarily they are negligible. The difference between the sum of the scores given and 100 will represent the total score for these other sense-departments.

Rank-orders. The distribution of rank-orders is shown in Table 1. Visual imagery ranks first for 103 (92 per cent) of

TABLE 1

Rank-orders	VAK	VKA	AVK	KVA	KAV	Others
No. of cases	88	15	0	0	1	5
Per cent of total	78.5	13.4	0	0	.9	4.5

the subjects, auditory first for 3 (2.7 per cent), and kinesthetic for 1 (.9 per cent).

The mean and median scores, standard deviations, and coefficients of variability are shown in Table A, Appendix II.

One reason for the great superiority of visual imagery revealed by this test is doubtless to be found in the fact that in the majority of our everyday experiences our attention is dominated by visual elements, and in the other fact that we tend to recall those elements of experience which dominated attention.

Frequency Curves. The frequency curves (see Appendix II, E) are nearly normal for visual and auditory imagery, and greatly skewed for kinesthetic, with S 82m enjoying an isolated position.

While it is hardly worth while to give the distribution of responses for each word, yet one word gave particularly interesting results. About 95 per cent of the responses to the word "expansion" were kinesthetic. When a word was pronounced the majority of subjects would wait until after the beginning of an inspiration and then report "kinesthetic." Of course it is natural for an inspiration to occur just before speaking, but it was unnoticed by the subjects in responding to other words. A few responses had to be recorded as imageless, as the subject was unable to detect any imagery. Visual imagery was aroused for

a few of the most visual subjects. In one case there was a visual image of expanding rails; in another case an image of an expanding balloon; and in a third case there was a rhythmical drawing apart and together of the parentheses.

Intra-Test Correlations. These correlations, for 112 subjects, are:

Visual and auditory	—.62
Visual and kinesthetic	—.68
Auditory and kinesthetic	—.02

The fact that two of these correlations are fairly large negative values does not in itself mean that they contradict the conclusions drawn from the positive intra-test correlations for Test 1. In Test 1 a high score for any one kind of imagery did not automatically reduce the sum of the scores for the other kinds, as it was possible for each kind of imagery to receive a score of 100 in that test. The sum of the scores therefore varied from subject to subject. But in Test 4 the total of all the scores for the different kinds of imagery was fixed (seven times the number of items), and therefore the same for all subjects. As a result, the higher the score for any one kind of imagery, the lower must be the sum of the other scores. Under such conditions a zero or small negative correlation really indicates the existence of some sort of linkage. It is also true under these conditions there would be a fairly large negative correlation if the processes measured are in reality independent.

The first two correlations indicate that as the visual increases in dominance, both auditory and kinesthetic decrease almost equally. But as the auditory increases it does so more at the expense of the visual than of the kinesthetic. Yet a study of the scores for the individual subjects shows that in every case where auditory was first, visual was second. This is consistent if we regard the visual and the auditory as the main contenders for the dominance of attention. The auditory, however, is somewhat stronger than the kinesthetic and can therefore hold its own against the visual more successfully than the kinesthetic can.

The situation with regard to the kinesthetic is still more complex. The second and third coefficients and my own observations

while conducting the experiments confirm the position of Egger, who suggests that the kinesthetic is always present, being noticed only when the visual and auditory are too weak to dominate the field. Yet since the auditory is weaker than the visual (see results of Test 1), it ought to disappear before the visual, leaving some visual and some kinesthetic, therefore resulting in a greater correlation between visual and kinesthetic than between auditory and kinesthetic. But that this is not true is indicated by the above correlations. A possible way out of the difficulty is to assume that the *entente* established in the verbal field between auditory and kinesthetic verbal imagery is carried over into the field of concrete imagery, thus tending to cause the visual to drop out before the auditory. In Test 1 there was a correlation between kinesthetic and auditory imagery but not between the kinesthetic and the visual.

The above discussion is based on the general tendencies revealed by the group. Exceptions to almost every rule are to be found by studying the individual results in Table A of Appendix II. Most of these exceptions are genuine, although some may be due to the unreliability of the results of some of these subjects.

Effect of the Method of Presentation. The last 50 words and the first 20 sentences were given twice to Group D, once orally, once visually. The mean scores for words and for sentences, with auditory and with visual presentation, are shown in Table 2.

TABLE 2

Material	Method	Vis.	Aud.	Kin.
Words	Visual	53.4	22.0	17.0
Words	Auditory	50.0	22.2	20.5
Sentences	Visual	57.0	32.5	11.6
Sentences	Auditory	54.0	34.0	11.6

It is evident that, for the group, there is very little if any difference resulting from the two methods of presentation of the stimulus words or sentences. In each case there is slightly more visual with visual presentation and more auditory with auditory presentation, but these differences are too small to be very significant. For some subjects there was a strong tendency to get more visual imagery with auditory presentation, and more auditory with

visual presentation, but for others the opposite was true. For the majority there was very little difference either way.

If the rank-orders are considered in this connection, we find that with auditory presentation, visual ranks first in every case but one (S 82m), but that with visual presentation visual ranks second to auditory for S 69w and S 104w. The order of rank for auditory and kinesthetic is reversed by 15 subjects. For two of these auditory ranks second for auditory presentation and third for visual presentation. For 13 of the 15 subjects auditory ranks second for visual presentation and third for auditory presentation.

With the sentences there were fewer changes in rank-orders with the change in the method of presentation, and therefore they present little new evidence. With the more complex stimulus the reaction is more likely to be the same in two cases,—since the relation of the different objects and the action in each case is fixed,—than if a single word is given.

The correlations between the results obtained by the two methods of presentation (visual and auditory) are:

Visual	.64	p.e.	.06
Auditory	.75	p.e.	.05
Kinesthetic	.56	p.e.	.07

The results shown in Table 2 also show that the sentences excited considerably more auditory imagery than the words. The results from the words may be more valid, in so far as greater freedom in association is possible with them. On the other hand, our thinking is ordinarily represented better by the sentence-form than by isolated words, and hence the imagery excited by the sentences may portray the distribution of our ordinary everyday imagery (concrete) better than that called out by words.

Individual Differences: Types. The data show a wide range of individual differences, but no evidence of the existence of types.

Sex Differences. Table 3 shows the average scores of men and of women for visual, auditory, kinesthetic, and for the sum of the various other kinds of imagery. This table shows that the men exceed the women in the use of the visual, but that the women have slightly more auditory and kinesthetic, although the last

difference is too small to be given much consideration. The lower scores of the women for visual are due in part to the slightly higher scores for auditory and kinesthetic, but are due more to the greater percentage of the other kinds of imagery, *i.e.*, gustatory, olfactory, temperature, touch, and pain. This difference in visual imagery cannot be traced to a few extreme cases. The most extreme case, that of S 82m, is a man with little visual or auditory but with 79 per cent of kinesthetic.

TABLE 3

	Vis.	Aud.	Kin.	Others
Men	63.0	21.3	11.8	3.9
Women	54.2	23.6	13.2	9.0

Reliability of the Test. The reliability of this test depends on the correct choice of materials and upon the reliability of the introspections. The latter depends on the ease of introspection and the honesty of the subjects.

Some light on all these points may be gained by comparing the results for words and sentences. This gives coefficients of correlation of .83 for visual, .69 for auditory, .68 for kinesthetic. The smaller coefficients for auditory and for kinesthetic are largely due to the smaller average scores, especially for kinesthetic. A small, and chance, difference in relation to the whole amount of imagery becomes great if considered in relation to the average for kinesthetic alone. The rank-orders were the same in 92 per cent of the cases.

More direct evidence was obtained from the last group of subjects (Group D) by correlating the results for two visual presentations of the first 25 words. These two presentations were at least one week apart, and the subjects were not expecting the repetition of the test. The coefficients are: for visual, .83, p.e., .03; for auditory, .73, p.e., .05; for kinesthetic, .89, p.e., .02.

These correlations are higher than I had expected to find with the short series of words and with untrained subjects. It is very probable that if the whole series of 75 words and 50 sentences had been given twice, the coefficients would have been still larger. As it is we can see that fairly valid results can be obtained by the use

of one-fifth of the material used throughout for this test. Yet I believe it safer to use the entire series.

Summary

1. Seventy-five words and 40 sentences or phrases were shown or read to the subject, who was instructed to think of the object and to report the kind or kinds of imagery aroused. If more than one kind were present, the subject expressed the relative dominance of each by a distribution of seven points. The total number of points assigned to each kind of image was then reduced to a percentage basis.

2. Visual ranks highest in 103 (92 per cent) cases, auditory in 3 (2.7 per cent) and kinesthetic in 1 (.9 per cent).

3. The average scores (per cent) for the group are: visual, 59.7; auditory, 23.1; kinesthetic, 12.4. The variability is greatest for the kinesthetic, least for the visual.

4. The presence of the visual is opposed to both auditory and kinesthetic. The auditory and kinesthetic tend to go together.

5. No definite effect of the mode of presentation can be determined from the available data, except for the greater amount of kinesthetic at the expense of visual with auditory presentation.

6. The ranges, S.D.'s, and V.'s show great individual differences, but there is little if any evidence favoring the type theory. The frequency curves are not multi-modal.

7. There are no clearly defined sex differences.

8. There is a high correlation between the results with words and with sentences.

9. The above indicates that the reliability of the test is high. The correlations between two trials one week apart with 25 words are: visual, .83; auditory, .73; kinesthetic, .89. These are based on results for 44 untrained subjects.

CHAPTER VI

Test 5. Dominance of Verbal Imagery

The scores for this test were secured from the following eight sources:

1. This includes the introspections of Test 6, in which six letters and numerals were pronounced to the subject, who immediately repeated them in reverse order. Introspections were taken twice, once at the middle and again at the close of the test.

2. This includes the introspections of Test 7, based on the immediate written reproduction in normal order of a series of eight letters and numerals presented visually and simultaneously. Introspections were taken twice, as in Test 6, and the whole test was given twice, on different days.

3. A series of letter squares containing nine letters and numerals each was prepared. Each square was exposed ten seconds, with delayed recall. During the interval between the exposure and the recall the subjects were required to do problems in mental arithmetic (multiplication) for thirty seconds. They were told that the purpose of the multiplication was partly to determine how many of the problems they could do during the series, and that they should not try to hold the squares in mind during this period. Introspections were taken three times.

4. The subjects were asked to recall the lines of some poems and to give introspections regarding the verbal imagery involved.

5. The subjects were required to multiply 23 by 46, 38 by 67, 62 by 19, and 93 by 57, mentally. Introspections were given at the close. When necessary additional problems were given.

6. The following questions were asked. The answers were based on a distribution of seven points as in previous tests.

a. "To what degree is your thinking in concrete imagery, and to what degree in verbal?"

b. "What kinds of concrete imagery are there? Distribute seven points with regard to dominance."

c. "What kind or kinds of verbal imagery? Distribute seven points between visual and inner-speech, and then between the auditory and kinesthetic elements in inner-speech."

7. This question was asked: "Is your silent reading accompanied by inner-speech? If so, to what degree is it auditory and to what degree kinesthetic?"

8. The subjects were also asked: "Is any inner-speech present while writing? If so, to what extent is it auditory and to what extent kinesthetic?"

Preliminary work had shown that in dealing with verbal imagery the best method is to request first a distribution of seven points between visual and inner-speech, and then an independent distribution of seven points between the different elements of the inner-speech. This procedure prevents the difficulty involved in the analysis of inner-speech from affecting the more fundamental division of verbal imagery into visual and inner-speech. It also makes the second division more reliable because the introspective problem is simplified.

The total number of points for visual and for inner-speech in the first division of points, and for the auditory and kinesthetic components of inner-speech in the second division were reduced to percentages of the total number of points in each division. The scores for inner-speech in the first division were then divided between auditory and kinesthetic according to the ratios of the scores in the second division. This procedure gives a distribution of seven points between the visual, auditory, and kinesthetic factors in verbal imagery; and although it is somewhat complicated from the standpoint of the investigator, it greatly simplifies matters for the subject.

Unanalyzed meaning frequently occurred in the second and third parts and to some degree in the first. When this occurred the division was made between visual, inner-speech, and "meaning" (for want of a better term). Whether or not this unanalyzed meaning necessarily involved imagery in every case is a question I am not prepared to answer. But because the subjects could report no imagery in these cases no other course was open.

It is better not to call for introspections too soon after begin-

ning a test, or too frequently. Too early or two frequent introspections result in the subject's thinking too much about the method he is using and about other possible methods, and at the close neither he nor the investigator can be sure how he would work under more nearly normal conditions. After about half any test has been completed the subject has become adjusted and is more likely to be using the method that is natural or habitual for him. This makes the introspections more reliable and they are not so likely to influence the method.

In determining the final scores for the whole of Test 6 the eight different parts were given equal weight.

Results

The scores for visual,[1] auditory, and kinesthetic, and for the last two as combined in inner-speech are given in Table B of Appendix II. The means, medians and measures of variability also appear in this table.

Visual ranks higher than inner-speech in 22 per cent of the cases. Inner-speech ranks above visual in 76 per cent. For two subjects they are equal. When the inner-speech is split into its two components, we find the following distribution, in per cent of the number of subjects, of rank-orders: VAK, 29; VKA, 16; V-AK (auditory and kinesthetic equal), 4; AVK, 20; AKV, 12; A-VK, 1; KVA, 4; KAV, 9; K-VA, 3. Visual ranks first in 49 per cent of the cases, auditory in 32 per cent, and kinesthetic in 16 per cent. It is probable that these results give the visual a higher place that it has in the ordinary daily life of these subjects, so far as verbal imagery is concerned. Parts 2 and 3 involve visual presentation and immediate recall and Part 1 has a strong tendency to bring out the visual. However, there is no apparent reason why the ratio of the auditory to the kinesthetic should not be approximately correct. The V's for the three kinds are more nearly equal than in the preceding tests.

[1] In discussing this and later tests of verbal imagery the terms "visual," "auditory," and "kinesthetic" will be used to refer to visual-verbal, auditory-verbal, and kinesthetic-verbal imagery unless otherwise specified. "Inner-speech," as is customary, is used to designate the auditory-kinesthetic combination or fusion.

The variability is fairly high. The S.D. and V for visual are higher than in preceding tests. The range for kinesthetic is made so large by subject 82m whose score is 98 per cent for kinesthetic. The next highest score for kinesthetic is only 59. The frequency curves are shown in Appendix II. Each of them is approximately " normal."

Intra-Test Correlations. (See Table D, Appendix II). The correlation between the scores for visual and inner-speech is —.84. This would be —1.00 were it not for the presence of unanalyzed meaning. The correlation of visual with auditory is —.44; and of visual with kinesthetic, —.49. It is possible that when inner-speech is mainly kinesthetic, visual-verbal imagery is less likely to be present than it is when inner-speech is mainly auditory. Although the difference between these coefficients is small it is in harmony with the results of Test 1.

The correlation between auditory and kinesthetic is—.40. As in Test 4, this is less than the other two just mentioned, but the difference is much less. In this test, as in Test 4, the sum of the scores must be 100, and the influence of this fact on the coefficients is the same as in that test. In this test (Test 6) the situation is further complicated by the fact that for some subjects there was nothing but inner-speech. For these subjects the scores for auditory and kinesthetic are opposed, *statistically,* and this results in a higher negative correlation than in Test 4, even though there is a much greater tendency for auditory and kinesthetic to go together here than in Test 4. The reader must be careful not to consider these intra-test correlations in Tests 4 and 6 alone, but relatively. There is no real contradiction or lack of harmony between these negative correlations and the positive intra-test correlations in Test 1.

In many cases a subject reported visual imagery in one part and inner-speech in another. On the other hand when auditory and kinesthetic are present in verbal imagery they are almost invariably present simultaneously. I found no clear case of the simultaneous presence of visual and kinesthetic without any auditory. Visual and auditory may appear together with the kinesthetic

absent. These facts probably are to be explained as the results of language habits. Most of our first verbal experiences are auditory and kinesthetic, and while talking these two elements are simultaneous and naturally become closely linked. At times we have experienced simultaneously the visual and auditory while watching the page as another reads aloud. But, while acquiring our language habits, if we experience the visual and kinesthetic sensations simultaneously, auditory sensations are likely to be present also.

Individual Differences: Types. The variability of the scores has already been discussed. The ranges of scores show great individual differences. But however great the individual differences may be, they offer no evidence either way with regard to the existence of types. No evidence of true types is furnished by the frequency curves. Subject 26m, who reported almost no auditory concrete imagery gave 13 per cent to auditory in this verbal test. Subject 82m reported nothing but kinesthetic (vocal) in this test. But his results are modified by the fact that he reported an almost constant tendency to try to visualize. He also said he is not sure about the auditory because, like many others, he had difficulty in analyzing his inner-speech. At times there seems to be an almost if not quite complete fusion of the auditory and kinesthetic components of inner-speech. Subject 34w is also exceptional. She gave 93 per cent to inner-speech and only 7 per cent to visual. Inner-speech for her is about equally auditory and kinesthetic.

It seems clear that in the verbal field the visual stands somewhat alone, while there is a strong tie between the auditory and the kinesthetic. But types of verbal imagery and types of individuals with regard to verbal imagery are different propositions.

Sex Differences. The average scores for men and for women appear in Table 4. Here, as in the other tests, the differences

TABLE 4

	Vis.	Aud.	Kin.	I-S
Men	36.5	28.3	26.4	55.6
Women	32.2	35.0	24.4	59.6

are not large. Nevertheless they agree with the results of Test 1 (clearness of concrete imagery) and Test 4 (dominance of concrete imagery).

Reliability of the Test. Time did not permit a repetition of the test, and a coefficient of reliability by that method was therefore not possible. Some evidence was secured by correlating the results of the first and second halves of the test. The result, .43, shows that the introspections were not due entirely to chance. This coefficient might possibly have been much lower, even though the coefficient of reliability for the whole test were 1.00, because of the difference in the nature of the first and second halves of the whole test. Because the introspections of Test 6 were used here, the correlations betwen the introspective and objective results of that test indicate at least some reliability of the introspections under such conditions.

On the whole, this test has less reliability than Test 4, as the introspective task of dividing inner-speech into its components is very difficult for many subjects.

Summary

1. Introspections were taken with regard to the verbal imagery present under each of eight different conditions, using the method of the distribution of seven points. The number of points assigned to each kind of imagery was reduced to per cents of the total number for all kinds.

2. Inner-speech ranks above visual verbal imagery for 76 per cent of the subjects.

3. When inner-speech is divided into its two components, visual ranks first for 49 per cent of the subjects, auditory for 32 per cent, and kinesthetic for 16 per cent.

4. The average scores are: visual, 34.9; inner-speech, 57.1. For the two components of inner-speech they are: auditory, 31.4; kinesthetic 25.7. Because some of the parts seemed to favor visual imagery it may be that the scores for visual are too high. For the women auditory ranked above visual.

5. The frequency curves are nearly normal.

6. The individual differences are large. There is no evidence of types of individuals, although we might be justified in a division of verbal imaginal experience into two main types—the visual, and the inner-speech combination.

7. The sex differences are not very large, although they agree with the results of other tests. The average of the men is higher than that of the women for visual verbal imagery and lower for the auditory.

8. The test has fair reliability, but not as high as in the tests of concrete imagery. It is not so difficult to distinguish between visual and inner-speech, but many subjects have difficulty in dividing the inner-speech into its components.

CHAPTER VII

Test 6. U-L, Backward Repetition

This test grew out of a futile attempt to find an objective test in backward spelling. Words, letters and numbers were used, but the scores for neither time nor accuracy of reproduction seemed to furnish a valid basis for direct objective scores. A test based on the kind of substitutions made in the backward repetition of letters was more promising, for as is well known, the more visual subject shows a tendency to confuse like-appearing letters, the auditory subject the like-sounding letters. The main difficulty with this method lies in the insufficient number of substitutions made by many subjects.

In the preliminary work it happened that two or three of the series of letters contained several letters with the same vowel sound, and it was noticed that those subjects who reported a great deal of auditory imagery had greater difficulty with these lists than with the others, and that this was not true of the more visual subjects. This fact naturally suggested that two series be prepared, one to contain like-sounding letters, the other to contain none. This was done. One or two digits were added to each list, for two reasons. The first was that not only is the number of vowel sounds somewhat limited, but also that the number of letters with some of these sounds is small, and no letter should be used too frequently. The other reason is that the presence of digits reduces the tendency to read meaning into the lists. The number of vowels and of digits was made approximately the same in the two series.

As similarity of sound must also involve some similarity in kinesthesis, this factor could hardly be equalized for the two series, although it was hoped that the data secured might show some way in which this might be done later. On the other hand, since at that time my main purpose was to find a means for detecting the presence of inner-speech as a whole, and because I

assumed (perhaps erroneously) that similarity would have the same effect for both the auditory and kinesthetic components, some additional similarity of kinesthesis was introduced into the like-sounding series. For example, *c* and *6* were placed in the same list as were also *k* and *q*.

Twenty series of letters and digits each were prepared, ten containing several like-sounding letters and ten containing no two letters or digits with similar vowel sounds (see Appendix). These numbers are rather small, but the time which could be allotted to the test was limited, and it was considered that this would be enough to determine whether the test had any real value.

The procedure and the method of scoring performance are explained in the instructions. The real purpose of the test was not mentioned to the subject, nor was anything said about the two kinds of lists, as this might result in an unequal distribution of attention. The instructions were as follows:

"I will repeat a series of six letters, or letters and numbers and you are to repeat them in the reversed order, and as soon after I finish as possible. I will start a stop-watch as I pronounce the last letter, and will stop it when you have finished. If you forget the letter for any position, say 'blank' when you come to that place, in order that I may know that you have the remaining letters correctly placed. In scoring, two points will be given for each letter correctly placed and one for each letter which belongs in the series but is incorrectly placed. Speed and accuracy in reproduction are of equal importance. You will not be told whether you succeed or not in correctly reproducing the series until after the completion of the test."

The U and the L series were given alternately. A few subjects began to notice something of the nature of the series toward the last of the test, and in these cases a more irregular order was followed.

The six letters were pronounced in eight seconds. The rate was regulated by a pendulum, hidden from the subject.

The objective scores for the presence of inner-speech are based on the difference in time and in reproduction, for the two kinds of series. The difference between the average scores for the like and the unlike sounding series gives the U-L for time, and the difference in the scores for accuracy gives the U-L for accuracy. For statistical purposes these may be considered singly,

or the two may be combined by averaging the two differences, either directly, or after reducing both to a ratio or percentage.

This difference between the average scores of the U and L series, which furnishes the measure of the presence of inner-speech (at least of the auditory factor), may be stated in either of three ways: (1) as the difference between the two (U-L or L-U); (2) as the ratio of either to the other (L/U or U/L); and (3) as the ratio of the difference to either of the averages. It is evident that in general the score of the U lists, which do not contain the disturbing factor, should serve as the basis in each case. However, the matter is complicated by the fact that the scores for time are in reality inverse measures of the factor with which we are really concerned, which is speed. These "time" scores could be changed to relative "speed" scores by taking the reciprocal for each, and the U-L could then be computed from these. A simpler method, and for our purposes just as effective, is to compute the U-L of the time scores, and change the algebraic sign, thus giving a U-L for speed.

The following rules should be observed in giving the test.

1. Do not tell the subject how well he succeeds in correctly reproducing any series until the test has been completed. It is desirable that the subject use the most natural method, and the knowledge that he may not be succeeding as well as he thinks may lead him to experiment with other methods.

2. The rate of presentation must be constant. A swinging pendulum, unseen by the subject, is convenient and noiseless.

3. The letters must be pronounced evenly, without accent or rhythm.

4. The U and the L series must be given alternately, or at least in irregular order, as most subjects change their method somewhat, most frequently in the first half of the test.

5. The arrangement of letters should be such as to reduce meaningful association to a minimum. Reproduction in reverse order tends to eliminate meaningful association.

6. Use a short practice series. The subject should not know that any but the first one or two are for practice.

7. The same letter should not appear in successive lists, and

several seconds should be allowed between lists. If each one is scored before proceeding with the next a sufficient interval will ordinarily result.

Although when a larger number of subjects are tested a short test is sufficient to determine general tendencies, establish norms, etc., yet ordinarily a longer series should be used. An additional series for this purpose is given in the appendix.

The possibility was considered that the results (U-L's) are a function, not of the kind of imagery involved in recall but the mode of presentation or of reproduction. To test this similar lists were prepared to be presented visually, and simultaneously, reproduction to be written, in normal order, thus changing nearly every factor but the one it was desired to test, *i.e.*, the effect of the similarity of sound in the "L" lists. This has been given the status of a separate test, Test 7 of the present series. A comparison of the results of the two tests will be found in Chapter VIII.

It may be possible after more extended work to find in a comparison of the effects on time and accuracy, a means for further differentiating subjects, possibly with regard to the relative strength of the auditory and kinesthetic elements of inner-speech. Until then and probably after, the effects on time and accuracy (*i.e.*, the U-L for each) should be combined as some subjects sacrifice speed for accuracy, and some accuracy for speed. Whether this last difference in individuals is due to chance or to some factor which the test can be made to reveal remains for further work to determine.

Results

Detailed results of this test are given in Appendix II, Table B. In columns 3 to 7 are given the results of the introspections of the subjects, based on a first distribution of seven points between visual, inner-speech and meaningful associations; and a second distribution of seven points between the auditory and kinesthetic components of inner-speech. For correlating, etc., the results for visual, inner-speech and "meaning" can be taken directly from

columns 3, 4, and 5, respectively. But to obtain scores for such purposes, the values given in columns 6 and 7 must be considered in relation to the values in column 4. The simplest way to do this is to multiply the value in column 4 by that in column 6 for auditory, and by that in column 7 for kinesthetic. Of course the values in column 4, for inner-speech, could be divided in the ratio of the values for auditory and kinesthetic in columns 6 and 7. This would give us a single distribution of points, but would involve fractions, and would make it harder to determine at a glance the relative importance of the auditory and kinesthetic components of inner-speech.

U-L's are given separately for speed, accuracy in reproduction, and for the sum of the two in columns 8, 9 and 10. The total relative effects of the like-sounding elements on speed and accuracy obtained by using the formula, $\frac{U\text{-}L}{U}$, are given in the 11th column of the same table.

These results show that for 8 per cent of the subjects, the speed of reproduction was less in the "L" than in the "U" series, and that for 80 per cent the accuracy of reproduction was less. The correlations with the introspections (Table 5) show this to be due to the presence of inner-speech and particularly of the auditory component. This table shows that the correlation between inner-speech and the U-L's for speed is .38, for accuracy is .43, and in the two combined is .49. In considering the size of these coefficients we must remember that the introspections are by no means infallible. This fact in itself tends to reduce the coefficients of correlation, so that even if the objective side of this test were perfect the coefficients would hardly be much higher. As a result of my experience with the test and with the subjects I would not hesitate in case of conflict between introspections and the objective results of this test, to accept the latter in preference to the former, if sufficient data are obtained to bring the probable error down to a third or less of the U-L.

Considerable light is thrown on the test by a comparison of the separate effects of auditory and kinesthetic imagery on the

differences in scores for the U and the L lists. The coefficients of correlation of differences in speed, accuracy, and of the sum of the two, with the visual, auditory and kinesthetic imagery reported in the introspections are presented in Table 5.

TABLE 5

Correlations Between the U-L's and Introspections in Test 6

	Vis.		Aud.		Kin.		I-S	
	r.	p.e.	r.	p.e.	r.	p.e.	r.	p.e.
U-L(S)	—.30	.06	.50	.05	.03	.07	.38	.06
U-L(A)	—.40	.05	.35	.06	.27	.06	.43	.05
U-L(S + A)	—.40	.05	.53	.05	.12	.06	.49	.05
$\frac{\text{U-L}}{\text{U}}$(S + A)	—.40	.05	.49	.05	.12	.06	.42	.05

It should be noticed that the presence of inner-speech affects the U-L for both speed and accuracy. The correlation between inner-speech and U-L(A) is higher than that between inner-speech and U-L(S), although neither is as high as that between inner-speech and U-L(S + A). The sum of the two differences seems to be a more accurate index of the presence of inner-speech than either taken separately.

It is evident that the presence of auditory imagery affects both U-L(S) and U-L(A). This means that when auditory imagery is present, the scores for speed and accuracy are less when there is a similarity of sound in the material presented. The correlation between auditory imagery and U-L(S) is higher than that between auditory imagery and U-L(A), the former being almost as large as that between auditory imagery and U-L(S + A). Yet since auditory imagery is correlated with the differences in both speed and accuracy it is probably safer to combine the two.

None of the correlations with kinesthetic imagery are high. Kinesthetic imagery apparently has no effect on U-L(S), which is the one most affected by the auditory. The correlation between kinesthetic imagery and U-L(A) is higher than the correlation with the sum of the two differences combined. Since the division of inner-speech into its two components is much more difficult than the division between visual-verbal and inner-speech, it may be that this fact will account for the lower correlations, on an average, between the separate differences and the introspections,

than between the sum of these differences and introspections. There is some indication that more accurate introspections would show U-L(S) to be correlated with auditory and U-L(A) with the kinesthetic.[1]

The correlations of all the indices with visual imagery are negative. These coefficients would be larger were it not for the frequent presence of the meaningful associations which many subjects could not analyze. For some reason more of these meaningful associations were reported by the last group of subjects. The correlation between visual and U-L(A) is somewhat higher than that between visual and U-L(S).

Individual Differences. The range of individual differences is large. The data presented in Table 6 show that there is a greater variability in the objective than in the introspective results, which is quite important from standpoint of method, since it indicates that the individual differences are probably greater than those revealed by the introspections of this class of subjects. The cases where U-L is negative nearly always occurred either with the subjects with a great deal of visual imagery, or else with those who appeared to have very little imagery of any kind.

The frequency curves for the U-L and $\frac{U\text{-}L}{U}$ values are shown

TABLE 6

	Mean	S.D.	V.	Range
Introspections				
Visual	2.09	1.17	.56	0 to 6
Auditory [2]	2.32	1.3	.33	0 to 6
Kinesthetic	1.77	1.3	.40	1 to 7
Inner-speech	4.09	1.7	.41	1 to 7
Objective Results				
U-L(S)	1.06	1.63	1.54	— 3.0 to 10.3
U-L(A)	.83	1.04	1.25	— 1.9 to 4.2
U-L(S + A)	1.89	2.25	1.19	— 4.0 to 11.9
$\frac{U\text{-}L}{U}$(S + A)	22.0	23.8	1.08	—34.0 to 97.0

[1] These statements are also true of the correlations between these indices and the scores for inner-speech in Test 5 (Dominance: Verbal). See Chapter IX.

[2] The means for visual and inner-speech are taken from columns 3 and 4 of Table B, Appendix II. Means for auditory and kinesthetic were obtained by dividing the scores for inner-speech according to the ratios of the figures in columns 6 and 7 in Table B. Other figures are from Table B.

in Appendix II, E. These curves are not as smooth as those of the results of the previous tests based on introspections. At the left of the curves there is a suggestion of a small group to which the term "type" might be applied, if this form of curve does not prove later to be due to chance sampling.

Sex Differences. The average U-L and $\frac{\text{U-L}}{\text{U}}$ for men and for women are: U-L for men, 1.82; for women, 2.01; $\frac{\text{U-L}}{\text{U}}$ for men, 20.24; for women, 25.02. The differences are not great, yet they become significant when it is remembered that in each of the previous tests the women have had higher scores for auditory imagery than the men.

Reliability of the Test. No coefficients of reliability are possible from the data secured. However, in about two-thirds of the cases the probable error of the difference is less than one-third of the difference. As stated above, a longer series should be used for testing a single subject. The time that could be allotted to this test in this series was limited, but it was hoped that the short series of the ten "U" and ten "L" lists would make it possible to determine general tendencies.

The correlations between the introspections and the U-L's are affected by both the reliability of the test and of the reliability of the introspections.

The most serious difficulty with the test is that even though it did furnish a valuable index of the amount of auditory imagery in backward repetition, we could never be sure that the same reliance upon auditory imagery would be found in other situations. The correlation is less with the introspections of a group of memory tests than with those of backward repetition alone. It is still less with the scores for verbal imagery in Test 5, and is practically zero with the results of the tests of concrete imagery. It is always dangerous to infer that any kind of imagery will be present in one situation because it is found in another.

Summary

1. Ten series of six letters and digits each with no like-sounding letters or digits (U series), and ten series each containing similar vowel sounds (L series) were pronounced to the subject, who was required to repeat them in reverse order as quickly as possible. The responses were scored in both speed and accuracy. The difference (U-L) in the scores for the two kinds of series furnishes the index of the presence of inner-speech. Differences in accuracy, U-L(A), and in speed U-L(S) were considered separately and in combination, U-L(S + A). It was assumed that with the pure visualizer, the average scores for the two kinds of series should be the same. The similarity of the sound of the L series should be confusing only to the degree that auditory inner-speech is present.

2. The size of the U-L is affected more by the auditory than by the kinesthetic element of inner-speech. The auditory affects the U-L for speed more than for accuracy. For the kinesthetic the opposite is true, as the kinesthetic element seems to have no effect on speed. The U-L's correlate higher with the auditory element than with inner-speech as a whole. The difference in accuracy, U-L(A), furnishes a better index of the absence of visual imagery than the sum of the differences in speed and accuracy, U-L(S +A). The original scores for speed and accuracy of reproduction (not the U-L's) furnish no basis for an objective determination of the kind of imagery used.

3. The individual differences are great, and more so for the objective than for the introspective results.

4. The U-L and $\frac{\text{U-L}}{\text{U}}$ values are higher for women than for men. The differences are not large, yet they are in accord with the results of all the other tests, which have shown higher scores for women in auditory imagery.

5. The correlations with the introspections and the probable errors of the U-L's indicate a fair degree of reliability for the test. The main objection to any single test is that the imagery of any given subject may vary in different situations.

CHAPTER VIII

Test 7, U-L, Memory, Immediate Recall, Normal Order

A memory test was included as one of the parts of test 5 (Dominance: Verbal) in order to obtain introspections for this sort of work. Later I decided to arrange the material as U and L series as in Test 6, partly to determine the result of changing all the conditions of the latter test except the one regarded as fundamental; *i.e.*, the division of the material into U and L series. The other reason was the possibility that the new arrangement might give results as valuable as those obtained by Test 6. If it should do so, it would have the advantage of being a group method. This new arrangement of material would not affect the value of the introspections for use in Test 5.

Three sets each containing ten U and ten L series were used. Willson's gummed letters, black, one and one-half inches high were used, placed two and three-eighths apart on a white cardboard.

The formula, U-L, was used on account of the number of subjects who made perfect or nearly perfect scores. If practicable the number of letters in each series should be longer, thus increasing their difficulty, but this cannot very well be done on account of the limited number of sounds represented in the alphabet, and of the limited number of letters for some of these sounds, and because no letter should appear too frequently, nor should it appear more frequently in the L than in the U series. However, in practice these rules cannot always be followed exactly.

Thirty-five seconds were allowed between exposures. This permitted a rest of from ten to fifteen seconds after each recall. This was done to reduce fatigue, and also to reduce the possible influence of perseveration.

A comparison of the results with the results of Test 6 will be made in the next chapter. In general it may be said that the results verify the validity of that test. This test has less value

than the other because it lacks two of the chief elements of value in that test, namely, backward repetition, and scores based on both time and accuracy in reproduction. By individual testing scores for time could be obtained by this method. It would hardly be feasible to require backward repetition of material presented simultaneously.

The effect of substituting successive for simultaneous presentation of the same material was tested with an outside group of about fifty students. An apparatus was constructed which would expose the letters on these cards either simultaneously or successively. For successive presentation an opening in a screen moved in front of a card at a constant speed, which could be regulated at will. The screen moved from left to right. The apparatus was noiseless, as a test for auditory imagery must avoid auditory distractions, especially since these distractions have different effects on different people, irrespective of the kind of imagery they may have. This variation is only one of several which will be tried in the future. As this variation in method was used with an extra group of subjects no results will be reported here, except to say that there is very little difference in the average size of the U-L's obtained by the two methods of exposure.

It may be that still better results may be obtained from visual successive presentation, with verbal reproduction in reversed order, time and accuracy in reproduction to be scored as in Test 6.

Results

This test was given to Groups C and D, 72 subjects in all. In 69 of the 72 cases U-L[1] is positive. The average U-L is 11.1, which is about the same as the U-L(A) in the previous test. The median is 12; the S.D., 7.3; the V., .66.

The U-L's were correlated with the introspections of this test, with the objective indices from Test 6, and with the introspections of Test 5. The correlations between the U-L's and the scores

[1] As there was no means for determining the speed of reproduction in this test, the U-L refers to differences in accuracy only, being comparable to U-L(A) in Test 6.

of the different kinds of imagery, according to the introspections in Test 7 are:

U-L and Visual Imagery, —.17, p.e., .08
U-L and Auditory Imagery, .29, p.e., .07
U-L and Kinesthetic Imagery, .21, p.e., .08
U-L and Inner-Speech, .33, p.e., .07

Between the U-L's in Test 7 and the scores in Test 6, the correlations were:

U-L, Test 7, and U-L(S), Test 6, .04, p.e., .08
U-L, Test 7, and U-L(A), Test 6, .46, p.e., .06
U-L, Test 7, and U-L(S + A), Test 6, .09, p.e., .08

Between the U-L's, Test 7, and the scores for the different kinds of imagery in Test 6, according to the introspections, the correlations were:

U-L, Test 7, and Visual Imagery, Test 6, —.017, p.e., .08
U-L, Test 7, and Auditory Imagery, .21, p.e., .08
U-L, Test 7, and Kinesthetic Imagery, —.024, p.e., .08
U-L, Test 7, and Inner-Speech, .142, p.e., .08

The U-L's in this test show practically a zero correlation with the total difference, U-L(S + A), in Test 6, but a correlation of .46 with U-L(A) in that test. As Test 7 is limited to differences in accuracy or reproduction the last comparison shows that there is considerable agreement between this and the part of the other test that is really comparable, although the conditions were greatly changed. With a change in the conditions there is ordinarily some change in the kinds of imagery used.

The first set was exposed seven seconds, the second six, and the third five, as it could not be determined beforehand just what exposure period would be best. A too brief exposure prevents the subject from learning the list by inner repetition in inner-speech, unless it is completed after the exposure. As the exposure period is lengthened there is a gradual increase in the number of meaningful associations, and in the various mnemonic devices hit upon by the subject, both of which reduce the validity of the results, and the average of the U-L's is reduced. This was shown quite clearly in work with a separate group to whom the three sets were shown 5, 10, and 15 seconds, respectively. However, there

is little difference in the size of the U-L's for the three different rates used with Groups C and D.

Sex Differences. The average U-L for women is 12.4; for men it is 10.5. This agrees with the results of Test 6.

Reliability of the Test. There are three main reasons why this test does not give as valid results as the one using backward repetition and which considers both speed and accuracy. The first is the greater introspective difficulties[2] encountered in this test, which result from the simpler nature of the task, and from its greater tendency to arouse meaningful associations. The second is that so many subjects make so nearly perfect scores in both " U " and " L " lists, which automatically reduces the U-L's for these subjects. The third is that only difference in ability to reproduce is considered in this test, while the results of the previous test showed that difference in speed gives a more accurate index for auditory imagery, and that the sum of the two differences gives a more accurate index of inner-speech than either difference considered alone. An additional objection to this test is that the series used must be about three times as long as the series in Test 6 to give results with as low a probable error.

Summary

1. The principle of this test is similar to that of Test 6. In this test series of eight letters each were presented visually for immediate written recall. One-half of the series contained several like-sounding letters; the other half contained none. The difference in the average scores furnishes the index. The scores are based on accuracy of reproduction only.

2. U-L is positive in 96 per cent of the cases. There is a correlation of only .334 with introspections. This is partly due to the relatively low value of the introspections in this test.

3. There is a correlation of .46 between U-L in this test and

[2] If the validity of an objective test could be otherwise established, a lack of correlation with introspections would affect the test only in indicating the great need for its existence.

U-L(A) in Test 6. As the conditions of the two tests are different, and as there is generally some change of imagery with a change in conditions, this correlation verifies the validity of the fundamental assumption in each, *i.e.*, that like sounding letters will confuse only to the degree that inner-speech is present.

4. The average U-L is larger for the women than for the men. This agrees with the results of all other tests.

CHAPTER IX

Inter-Test Correlations

The purpose of this chapter is to bring together the results of the different tests. The correlation table may be found in Table D of Appendix II. The separate results of each test are given in Table A and B of Appendix II.

Comparisons will be made, first between the results of Tests 1, 4, and 5, to be followed by a comparison of the results of Tests 2, 3, 6, and 7 with each of the other tests of the series.

Test 1 (Clearness: Concrete), Test 4 (Dominance: Concrete), Test 5 (Dominance: Verbal)

If the mean scores, standard deviations, coefficients of variability, and the ranges of the scores for each kind of imagery are compared it will be seen that visual ranks higher than any other kind of imagery in each test. The only exception is to be found in the scores for women in Test 5, where the average for auditory is slightly higher than for visual. The greatest variability (V) is found in the scores for kinesthetic and the least for visual, although this is not always true of the standard deviations.

There is less difference in the clearness of the different kinds of voluntarily aroused imagery than there is in the percentages of each kind of imagery present when no effort is made to excite any particular kind. The differences found therefore are not the result so much of differences in native equipment as of differences in training, lines of work, and other factors, which may include the indirect results of sensory defects, native or acquired. The fact that kinesthetic on the average is more nearly equal to the other kinds in Test 1 in Test 4 indicates that attention is ordinarily dominated by extero-ceptive presentations, although when occasion demands, attention may be dominated by the kinesthetic. A definite impression was formed as a result of working with the subjects that there is considerable correlation

between dominance of kinesthetic imagery and "self-consciousness."

The question may be raised as to why the results of the two "dominance" test (4 and 5) were not averaged. The answer is that there is too great a difference between the relative use of concrete and verbal imagery. If sufficient data were available to determine this ratio for each subject, the results of these two tests could be combined by weighting the results of each according to the ratio found between concrete and verbal imagery.

The rank-orders are the same in all three tests for 23 (26.4 per cent) of the subjects. They are the same in some two of the three tests for 77 (89 per cent), and different in all three for 10 (11.5 per cent). Since one of the tests deals with verbal imagery, in which test (Test 5) inner-speech predominates over visual-verbal imagery for 76 per cent of the subjects, this correspondence of rank-orders is quite high.

Test 1 (Clearness: Concrete), and Test 4 (Dominance: Concrete)

Here the rank-orders are the same for 62 (71.2 per cent) of the subjects. For 18 of the remaining 25 (28.8 per cent) subjects the change is in the relative positions of the auditory and kinesthetic. The main reason for this is that in the majority of cases the scores for both are quite small, so that a small difference in the scores for either is enough to change the rank-orders.

In the three cases where there is a change in the relative positions of visual and auditory imagery it will be noticed that auditory ranks first in Test 1 and second in Test 4. The reason for this is that for this group of subjects a person with clear auditory concrete imagery always has good visual also, and since the majority of our experiences are predominantly visual, we find visual ranking first for these subjects in the dominance test.

In 92 per cent of the cases the same kind of imagery ranks first in both tests.

Inter-Test Correlations. The correlations between the scores

of the two tests are: for visual .58; for auditory .51; for kinesthetic, .43.

These coefficients between the different kinds of imagery in the two tests show that, for the group, relative clearness of any kind of voluntarily aroused imagery is correlated with the greater dominance of that kind in non-voluntarily aroused imagery. As the tests were given on different days more than a week apart, and since the methods of grading the images differ in the two tests, the tendency of the subjects to get into an introspective rut (which would give a spurious correlation), is reduced to a minimum. If the scores in Test 1 represented *absolute* instead of *relative* clearness, it is possible that these correlations would be higher. However, it is more probable that relative differences are the more important as factors determining the kind of imagery "used" most. A more complete discussion of the relation between clearness and dominance appears in the last chapter.

Test 1 (Clearness: Concrete) and Test 5 (Dominance: Verbal)

Because Test 1 deals with concrete imagery and Test 5 with verbal, there is less correspondence in rank-orders than was found in case of Test 1 and 4. Nevertheless the rank-orders are the same in 27 (31 per cent) cases. In 50 (57 per cent) cases the relation between visual and auditory is the same; in 61 (70 per cent) it is the same between visual and kinesthetic; in 60 (60.8 per cent) it is the same between auditory and kinesthetic. There is therefore some correspondence in the results of the test for relative clearness of voluntarily aroused concrete imagery and of the test for dominance of non-voluntarily aroused verbal imagery. The correlations between the scores of these two tests are as follows:

Visual, two tests,	r, .12	p.e., .07
Auditory, two tests,	r, .42	p.e., .06
Kinesthetic, two tests,	r, .29	p.e., .07
I-S, Test 5 and Vis., Test 1,	r,—.14	p.e., .07
I-S, Test 5 and Aud., Test 1,	r, .14	p.e., .07
I-S, Test 5 and Kin., Test 1,	r, .17	p.e., .07

These figures throw little additional light on the relation between relative clearness and use, except that there are positive correlations between the relative clearness of concrete imagery and the dominance of verbal imagery.

It should be noted that even these small correlations between inner-speech in Test 5 with auditory and kinesthetic imagery in Test 1 agree with the results of the intra-test correlations in that the correlation is higher with the kinesthetic than with the auditory component.

The relation between concrete and verbal imagery will be discussed further after the results of the next comparison have been presented.

Test 4 (Dominance: Concrete) and Test 5 (Dominance: Verbal)

The rank-orders are the same for 44 (39 per cent) subjects. Between visual and kinesthetic the orders are the same for 58 (55.3 per cent); between visual and kinesthetic for 80 (69.6 per cent); between auditory and kinesthetic for 85 (74.1 per cent).

The same kind of imagery ranks first in both tests for 50 per cent of the subjects. The inter-test correlations are as follows:

Visual, two tests,	r,	.27	p.e., .06
Auditory, two tests,	r,	.38	p.e., .05
Kinesthetic, two tests,	r,	.49	p.e., .05
I-S, Test 5 and Vis., Test 4,	r,—	.21	p.e., .06
I-S, Test 5 and Aud., Test 4,	r,	.10	p.e., .07
I-S, Test 5 and Kin., Test 4,	r,	.25	p.e., .06

The correlations between the scores for the different kinds of imagery in these two tests are higher than the corresponding correlations between the results of Tests 1 and 5, for the reason that Tests 4 and 5 are both tests for dominance, while Test 1 is a test for clearness.

Inner-speech is again found to be more closely related to kinesthetic than to auditory imagery, although the coefficients are hardly large enough to be of much if any value.

Test 2 (Visualization Compared With Test 1 (Clearness: Concrete), Test 4 (Dominance: Concrete), and Test 5 (Dominance: Verbal)

These correlations are shown in Table 7. The coefficients are the results of correlating the results of Test 2 with the scores of each kind of imagery in the other three tests.

The fact that Test 2 correlates higher with the test for clearness of voluntarily aroused imagery than with the test for dominance of non-voluntarily aroused imagery might be regarded

TABLE 7

	Inter-test Correlations					
	Tests 2 and 1		Tests 2 and 4		Tests 2 and 5	
	r.	p.e.	r.	p.e.	r.	p.e.
Visual	.27	.06	.12	.07	—.06	.07
Auditory	.45	.05	—.02	.07	.16	.07
Kinesthetic	.17	.06	—.14	.07	—.07	.07
Inner-speech	...	...	...	...	.03	.07

as evidence that the results of Test 2 depend more on innate than on acquired ability. Other evidence may be found in the fact that many of the best scores in this test were made by students who have had the minimum of geometry and kindred subjects.

It may seem paradoxical to find a higher correlation between the results of a visualization test (Test 2) and the scores for auditory in Test 1, than between the visualization test and visual in Test 1. Yet this is to be explained by the fact that all of the subjects with good auditory concrete imagery also have good visual. Another fact to be considered is that while the visual imagery of the poorer visualizers is indistinct, yet it was clearer than the rest of their imagery. This would cause their scores for visual imagery in Test 1 to be as high or higher than the average for the group, thus reducing the coefficient of correlation between the results of Test 2 and the scores for visual imagery in Test 1. If the scores in Test 1 could be regarded as absolute instead of relative scores the correlation would be higher in the case of the visual than of the auditory.

Yet even when the native visualizing ability of the subjects is equal, it is natural to suppose that practice will increase that ability.

The correlation with the visual in Test 4 is in agreement with this assumption, although it is very small. In this connection it may be seen that the correlations with auditory and kinesthetic are both small, but that the signs are both negative. That with auditory is practically zero, which might be expected since there are two opposing factors affecting this coefficient. The first is the correlation in clearness between visual and auditory imagery, which was found to be somewhat one-sided. The second is that the scores of the dominance tests are given as per cents of the total number of possible points. If the images were not weighted for dominance and the per cents were of the number of words the correlations with both visual and auditory would be positive.

Test 2 (Visualization), and Test 3 (Clearness: Fluctuation)

Group C only, 28 subjects took both these tests. The average scores in Test 2 for each grade in clearness of imagery are given in Table 8.

TABLE 8

	Grade in Clearness			
	A	B	C	D
Mean	601	1501	1846	1260
A.D.	163	484	575	....
Number of subjects	9	8	10	1

Test 2 (Visualization) Compared with Test 6 (U-L, B.R.) and Test 7 (U-L, Memory)

The correlations are given in the appendix and do not appear to have any definite significance. The same correlations for Group C alone (not given) show fairly large negative correlations.

Test 3 (Clearness: Fluctuation) Compared with Test 1 (Clearness: Concrete), Test 4 (Dominance: Verbal)

The average scores for each kind of imagery in Tests 1, 4, and 5 for the subjects with each grade of clearness as determined by Test 3 are presented in Table 9.

Very few conclusions can be drawn from this table. The differences are not large enough to be important in themselves, yet

because they agree in general with the results found in other connections, they may have some significance. The relations shown by the average scores in Test 1 for each grade in clearness in Test 3 agree with the correlations between Test 2 and Test 1, which are also tests for clearness. The greatest difference here is seen for auditory imagery, which agrees with the results of the comparison of Tests 2 and 1. There is also some negative relation with kinesthetic imagery.

TABLE 9

	A	B	C	D	E
Vis. Test 1	88.0	85.2	86.5	83.0	
Aud. Test 1	71.8	72.1	62.4	39.8	
Kin. Test 1	54.0	64.3	56.0	56.2	
Vis. Test 4	68.8	58.8	60.5	68.0	74.0
Aud. Test 4	18.1	24.0	18.5	13.0	10.0
Kin. Test 4	7.1	11.6	9.96	14.5	7.0
Vis. Test 5	39.6	34.4	39.7	38.4	43.0
Aud. Test 5	30.2	34.9	28.2	25.2	30.0
Kin. Test 5	21.5	25.7	27.7	34.8	27.0

Test 3 (Clearness: Fluctuation) Compared with Test 6 (U-L, B.R.), and Test 7 (U-L, Memory)

The indices in Tests 6 and 7 for each grade of clearness in Test 3 are given in Table 10. It should be noticed that the U-L's are

TABLE 10

	Test 3. Clearness: Fluctuation				
Test 6	A	B	C	D	E
U-L(S)	.51	1.13	1.18	.20	.90
U-L(A)	.20	.86	.77	.68	—.70
U-L(S + A)	.71	1.99	1.95	.88	.20
$\frac{U\text{-}L}{U}$(S + A)	9.60	18.50	21.80	9.00	.20
Number of cases	19	20	23	5	1
Test 7					
U-L	1.10	1.14	1.58	1.20	
Number of cases	9	8	10	1	

smaller for grades A, D, and E than for grades B and C. As the conditions of Test 6 favor the presence of visual imagery the better visualizers are more likely to use it and thus reduce their U-L's. The poorest visualizers have little clear imagery of any

kind unless it be kinesthetic, and kinesthetic imagery has little effect on the size of the U-L. Some of the subjects in columns D and E are almost imageless.

Test 6 (U-L, B.R.), Compared with Test 1 (Clearness: Concrete), Test 4 (Dominance: Concrete), and Test 5 (Dominance: Verbal)

The correlation of U-L (S + A), Test 6 with each kind of imagery in each of the other tests named are shown in the Appendix.

These coefficients are very small. The correlations with the results of Test 1 are all almost zero except in the case of the visual, which may indicate that the one with better visual concrete imagery is more likely to use it in Test 6, which deals with verbal material.

Some subjects were found (see results of Test 1) with good visual concrete imagery but with poor auditory, yet none of these subjects had good auditory and poor visual concrete imagery. Therefore those with good auditory imagery will probably have good visual imagery, which they may use in Test 6 instead of the auditory, thus reducing the U-L's of those subjects. This may account for the lack of correlation between the U-L's and the scores for auditory imagery in Test 1.

The correlations between the U-L's and the results of the two dominance tests (Tests 4 and 5) show the same tendencies that were found in the correlations between the U-L's of Test 6 and the introspective data of that test.

Test 6 and Test 7

See the discussion of the results of Test 7, Chapter VIII.

CHAPTER X.

Summary

A summary of the results of each test is given at the end of the corresponding chapter, and in Chapter IX the results of inter-test comparisons and correlations are discussed. There is no need to duplicate these discussions, conclusions and summaries here. The following will be only a general summing-up of the results of the whole investigation.

Relation Between Clearness and Dominance (or Use). An average correlation of .51 was found between relative clearness and dominance of the different kinds of imagery, where both tests deal with concrete imagery. The average correlation between relative clearness of concrete imagery and the dominance of verbal imagery is .27. The clearness of verbal imagery was not tested. It has generally been assumed that the person whose visual imagery is clearer than the other kinds will use [1] more of the visual, than does the average person. Yet different writers have reported individual exceptions to the supposed rule. Some of the most visual-minded of my subjects do not have clear distinct imagery of any kind. Subject 46w is even more predominantly visual than her scores in the dominance tests indicate. Yet her visual imagery is vague and indistinct, and the other kinds even more so. The results of Tests 2 and 3 also show her to be below the average in ability to visualize.

The distinction between intra- and inter-individual comparisons (see Chapter I) is important in the consideration of such cases. In a direct inter-individual comparison of absolute (not relative) clearness of visual imagery, S 46w would rank near the bottom. Yet as she has a great deal more visual imagery than the average person, and in this regard ranks high, she apparently furnishes an

[1] The term "use," as a noun or a verb, is used throughout this report merely on account of its convenience. Strictly speaking, the expression may not be justifiable.

example of a negative relation between clearness and dominance. However, if we compare her visual to her other kinds of imagery we find it superior. On this basis therefore we can say in her case that the relative intra-individual superiority of visual imagery goes with the greater use of visual imagery.

Nevertheless, if a person's auditory imagery ranks higher than the visual in clearness on an intra-individual basis, or if his auditory imagery is clearer than that of the average, he will in all probability still use more visual-concrete than auditory-concrete imagery, because in every day activities, attention is generally dominated by visual sense presentations. It is for this reason that Segal holds that a quantitative superiority of visual imagery offers no evidence that a subject belongs to the visual " type."

The Relation Between Concrete and Verbal Imagery. The correlations shown in Table C, Appendix II and the comparison of rank-orders in Tests 1 and 4 with those in Test 5 (see Chapter IX) furnish a basis for the comparison of concrete and verbal imagery. The comparison of rank-orders shows a somewhat higher degree of correlation than the coefficients of correlation. Both should be taken into consideration.

The results of the separate tests have shown that in the concrete field visual imagery nearly always ranks first, but that in the verbal field inner-speech ordinarily ranks first. When inner-speech is divided into two components, visual-verbal and auditory-verbal are about equal, visual ranking somewhat higher for the men and auditory for the women. Yet the coefficients of correlation and the comparison of rank orders shows a considerable correspondence between the results of Tests 4 (Dominance: Concrete) and 5 (Dominance: Verbal). On an average those subjects reporting more than the average for any kind of imagery in one of the tests also report more than the average for the same kind in the other test, even though in many cases the visual is reduced from the first place in Test 4 to second place in Test 5.

Yet exceptions are numerous. For two given subjects the distribution may be the same in the results of different tests in the concrete field but very different in the verbal. One reason for

this may be a difference in work which causes one to read more than he hears or speaks, another to speak more than he reads, another to hear more. Another factor may be found in the differences in the methods of learning to read. Spoken words are learned in much the same way by everybody. These words acquire meaning by direct association with the objects. But the printed word may be learned (acquire meaning) in either of two ways. Of these the more common is through the medium of the already familiar spoken word. The teacher or parent points to the word and pronounces it. In other cases, the printed word is learned through association with pictures, in which the mediation of the spoken word is avoided. In the first case silent reading will later be accompanied by inner-speech. Insofar as the second method is used, the amount of inner-speech will be lessened. The application of the second method is of course limited, but it may nevertheless have its effect. If there is some constant tendency, equal in two individuals, which leads to a greater use of visual imagery, their scores in Test 4 will be about the same, as the background of concrete experiences will average about the same for all. But if one of them learns to read only through the medium of the spoken word, and the other by a maximum use of pictures, the first will have more inner-speech and less verbal imagery than the second.

The correlations between inner-speech, in Test 5, and visual and with kinesthetic in both concrete tests (1 and 4) should be noted. The correlations between the scores for visual imagery is negative in both cases. The higher correlation between inner-speech and kinesthetic than between inner-speech and auditory imagery is also significant. Ordinarily the person with good auditory concrete imagery has good visual concrete imagery also, and hence might use more visual verbal imagery than the person with little auditory concrete imagery. The same rule does not apply to the relation between kinesthetic and visual, and as a rule the person who reports more kinesthetic imagery in Test 4 has poorer visual and auditory imagery. He therefore has little visual imagery of any kind, and his inner-speech is more kinesthetic than auditory, although the kinesthetic is likely to carry some auditory with it.

Sex Differences. The sex differences are small. However, in every test, the introspections as well as the objective results show higher scores for women than for men in auditory imagery. In most tests the men score above the women in visual imagery, and the average for the men is higher than the average for the women in Test 2 (Visualization). Although these differences are consistent throughout this whole series of tests, they are too small to be very conclusive and may possibly be due to chance in the selection of subjects.

"U-L" Test. Test 6 furnishes a method for an objective determination of the presence of inner-speech, particularly of the auditory element. Instead of making direct inter-individual comparisons of performances scores, a condition (similarity of sound, of memory material) is changed. This change affects results to the degree to which auditory verbal imagery is present. The difference in the scores of the unlike-sounding and the like-sounding series is taken as the index of the presence of auditory imagery in recall. Unfortunately, the correlations indicate that changed conditions frequently result in a change in the imagery; so, as in any test, because an individual has one kind of imagery in one situation, we cannot be sure that he will have the same kind in a different situation. Under some conditions, almost the most non-visual individual will report visual imagery. The work of Fernald, Shaw, and others have also demonstrated this.

Imageless Thought. I tried as far as possible or practical to eliminate the problem of imageless thought. Preliminary work had shown that the possible loss from so doing was more than compensated by the greater definiteness of the results. The instructions throughout were such as to bring out imagery which might have been absent under different conditions and with different material. In the preliminary work the material that tended to give "imageless" results was eliminated. Although some persons may object to this, I believe that a little work with untrained (and unbiased) subjects will convince anyone of its necessity. The results therefore offer little evidence either way as to the existence of imageless thought. Yet, in Test 3, for example,

some subjects were seldom certain when an image was present and when it was not, even when making an effort to keep the image. They were inclined to doubt that they ever had any imagery under ordinary circumstances. At the same time there is no doubt concerning the meaning, image or no image.

It was very interesting to find some subjects in doubt as to just what a visual image is. This was true of one of the very few advanced students in my list of subjects. Subjects 23m and 51w, for examples, asked in Test 3 whether they were simply to " think of the way a circle looks " or whether they were to see it, in imagination, as if it were really there. Each was quite capable of doing the latter although it required effort. As to the former, they declared that their mental content was undoubtedly visual in meaning, but that under such conditions there were no noticeable lines as there are when they really see it, in imagination. My experience with my subjects has convinced me that many individuals never have the latter experience but unhesitatingly refer to their experience as " visual." Yet the two subjects just mentioned would call nothing but the latter an image. Subject 23m called one " visual meaning " without any image, and the other a " visual image." There seems to be a greater difference than one of clearness or vividness only; and the reports in the introspections of " rings of phosphorescent light " and of " luminous halos " remind one of Titchener's suggestion of a possibility of a retinal factor in the " images of imagination." It may be that the " memory images " are unstable because the time and place localizations and the background of other objects arouse other associations too quickly. Any imagery that might be present may be obscured for the same reason, and it seems at times as though there were a fusion of images, as of sensations, in which the different elements cannot be distinguished. This would give the " *visual* meaning " with no reportable visual imagery. This explanation is at least suggested by the nature of many of the reports and is not incompatible with the existence of a retinal factor in the " images of imagination "; and at the same time is not dependent upon it.

This explanation of the lack of definite outline in " memory images " would also help to explain why the retinal factor is

present in some cases and not in others (if it is ever present), because when what seems to be a retinal factor is present it takes a little time to develop and the associations surrounding the "memory images" do not give the time necessary for this full development. The familiarity itself of the "memory image" is dependent upon the activity of more or less numerous association paths, and the absence of this familiarity in the "image of imagination" points to a smaller degree of this associatory activity. Of course, it is possible that the absence of associations in connection with the "image of imagination" is due to the greater attention value of the image itself when for some unknown reason the hypothetical retinal factor is present. This greater attention to the one thing would naturally be accompanied by a greater inhibition of extraneous associations.

On the whole, I am at present inclined to agree with James that some people have "no substantive imagery in any department of their sensitivity," if the emphasis is placed on the word "substantive." It might be difficult for many to conceive of an image that is not substantive. The non-substantive images for the present must be placed with the "visual meaning," mentioned above; and however we may finally dispose of them, I am certain that what many individuals unhesitatingly call "visual images," because unmistakeably visual in meaning, would not be called images at all by those who are blessed with the images of the more substantive sort.

Individual Differences: Types. The inter-test correlations between the scores for each kind of imagery in the test for relative clearness (Test 1) and the scores for each kind of imagery in the dominance tests, and the inter-test correlations between the tests of concrete and verbal imagery indicate that in any one individual there is likely to be some fairly constant factor which favors some kind or combination of kinds of imagery. Yet such factors are ordinarily so weak that they are overcome or overshadowed by the other factors which determine the kind or kinds of imagery that will be present in any given situation. It is possible that the positive correlations between the scores for any one kind of

imagery in the different tests are the results of an inertia of judgment. But the different conditions of the different tests and the fact that they were made on at least three different days in as many different weeks make it improbable that the correlations are the result of this factor alone. For it must be remembered that with very few exceptions these subjects had no preconceived notions regarding their " imagery type."

Most of the facts revealed by these tests are against the theory of simple types. Subject 26m, who rates his auditory imagery at zero or nearly zero in the tests dealing with concrete imagery reported considerable in Test 5, which deals with verbal imagery. Subject 82m is perhaps the least visual of my subjects, although with him the situation is complicated by the fact he constantly *tries* to visualize. If his scores were measures of a natural tendency to use instead of the efficient use of the different kinds of imagery, he would be classed as predominantly visual. He seems to be a natural-born visualizer without the ability to visualize.

In connection with the question of combination-types it should be noted that within the field of concrete imagery the visual imagery is dominant for the great majority of subjects; although in the field of verbal imagery the visual is subordinated to inner-speech for the same subjects, and is almost or altogether lacking for a few. Because of the individual differences in the relative use of concrete and verbal imagery it is probable that the majority of those individuals who are said to belong to the " visual type " are " concrete " thinkers, and that those classed as " auditory-motor " are " verbal " thinkers. A bi-modal curve might possibly be found if the relative amounts of verbal and concrete imagery were determined with a large group of subjects. If so this would furnish some justification for the common belief that individuals can be classed either as visual or as auditory-motor. Whether it is some factor which favors the use of visual imagery for one individual, and some other factor which favors the use of auditory-motor imagery in another, which leads one to be a non-verbal and the other a verbal thinker, or whether this statement must be reversed is a question to be answered by further investigation.

In this connection it may be pointed out that the frequency curve for the objective U-L series in Test 6 are not multi-modal.

As they stand, the data furnish no evidence of the existence of combination-types (different combinations of imagery that are typical for different groups of individuals); although there are some facts which seem to indicate that visual imagery tends to stand alone and that the auditory and kinesthetic tend to go together.

Ordinarily the question of terminology is of minor importance. However, the use of the term, "imagery type" has been unfortunate and misleading. There is a tendency, pointed out in the first chapter, on the part of the few writers to continue the use of the term, but to re-define it. Instead of using the term "type" to refer to a homogeneous group of individuals who resemble each other more than they resemble individuals in another group, they use it merely to refer to the extremes of a normal distribution. To this use of the term there are at least three serious objections.

(a) If the term "type" is thus to be defined, what will take its place where it is now used correctly? If the term is used in both senses the result will be confusion of terms and consequently of thinking.

(b) Those who would thus re-define the term still seem almost unavoidably led to make attempts to classify the majority of individuals, who cluster rather closely about the average, according to these extreme deviations. This means of course that the majority of individuals are classed or described erroneously. An individual is classed according to his direction from the average and then, once "tagged," is thought of in terms of the individual at the extreme end of the scale, even though he is much nearer the mean than the extreme end of the scale. Some of those who use the term in this new way may be able to avoid these errors in their own thinking, but it is not likely that many of their readers or hearers will do so.

(c) Another objection to the continued use of the term "imagery type," however defined, is that there has never been any agreement as to the basis on which the classification of imagery types is to be made. The result has been that one writer

bases his classifications upon intra-individual comparisons, another upon inter-individual comparisons. The first classifies an individual according to the kind of imagery which for him is clearest, or most frequent or dominant, whereas the second classifies an individual according to his deviation from a group average. But that is not the whole difficulty. Some, in their classifying, have in mind qualitative aspects such as clearness, while others have in mind mere frequency or dominance. Taking these two problems together, we have four different bases for classification, each of which has been used. *To assume that individuals belonging to hypothetical types will be similarly classified on the different bases is at once to run counter to the facts.*[2]

The inevitable result of the use of the term in connection with individual differences in imagery has been the obscuring and overlooking of the real ways in which individuals do differ. Another result has been the failure to see the facts and problems in the field of imagery that are of considerable significance for general psychological and neurological theory. Little else can be expected as long as some writers use the term in its strict sense, and others use it simply to refer to extreme variations; and as long as either of these groups base their type-classifications of any one of four different bases, with the consequent differences in the "type" to which any given individual is assigned. Any adequate descriptions of an individual's imagery must include separate statements regarding the quantitative and qualitative aspects of concrete imagery, and the same for verbal imagery; and based on both inter-individual and intra-individual comparisons. This demands at least eight separate statements, and for some purposes, even more information will be required.

[2] See Chapter I, and the data in the appendix.

APPENDIX I

Material for the Tests

Test 1. Clearness of Concrete Imagery

(For instructions, see Chapter IV.)

1. Kin. Opening an umbrella.
2. Vis. Features of the members of your family.
3. Aud. Ringing of bells.
4. Tem. Heat from the sun's rays.
5. Kin. Using the telephone.
6. Vis. Rose.
7. Gus. Something sour.
8. Vis. Lightning.
9. Tac. Pain of a pin scratch.
10. Aud. Violin.
11. Vis. Violin.
12. Kin. Clapping the hands.
13. Aud. Clapping the hands.
14. Kin. Reaching for a pencil.
15. Vis. Lamp.
16. Kin. Writing with a pen.
17. Aud. Whistle of a locomotive.
18. Kin. Walking down stairs.
19. Vis. Scissors.
20. Aud. Rattling of a newspaper.
21. Kin. Using a toothbrush.
22. Tac. Pressure on the arm.
23. Gus. Chocolates.
24. Aud. Rain beating against the window pane.
25. Tem. Hand in cold water.
26. Tac. Pain of an object in the eye.
27. Olf. Apple blossoms.
28. Vis. Book.
29. Aud. Water running from a faucet.
30. Vis. Inkstand.
31. Kin. Passing a dish at the table.
32. Vis. Umbrella.
33. Aud. Closing a book.
34. Tac. Coarse cloth.
35. Aud. Typewriter.
36. Vis. Typewriter.
37. Kin. Using a hammer.
38. Aud. Striking of a clock.
39. Tem. Cold feet.
40. Olf. Onion.
41. Vis. Shoe.

42. Kin. Putting on a shoe.
43. Aud. Closing a door.
44. Kin. Using scissors.
45. Vis. Toothbrush.
46. Aud. Voice of lecturer, last class lecture.
47. Kin. Unfolding a newspaper.
48. Gus. Orange.
49. Olf. Cheese.
50. Tem. Cold wind.
51. Vis. Kitten.
52. Aud. Clinking of glasses or dishes.
53. Vis. Automobile.
54. Olf. Kerosene.
55. Vis. Postage stamp.
56. Kin. Nodding your head in assent.
57. Tac. Pain, from a burn.
58. Kin. Drawing a circle on paper.
59. Aud. Report of a gun.
60. Gus. Vinegar.
61. Tac. Pain, sore throat.
62. Vis. Church building.
63. Tem. Heat from stove or radiator.
64. Aud. Ringing of the telephone.
65. Kin. Putting on a coat.
66. Vis. Telephone.
67. Tem. Cold, ice cream in the mouth.
68. Aud. Dog.
69. Kin. Throwing a ball.
70. Vis. Fire engine.
71. Gus. Salt.
72. Vis. Watch.
73. Kin. Reaching up to a high shelf.
74. Aud. Rattling of leaves.
75. Gus. Milk.
76. Tem. Cold, snow or ice in the hand.
77. Vis. Clock.
78. Aud. Chirping of insects.
79. Olf. Rose.
80. Kin. Lifting a weight.
81. Vis. Flag.
82. Gus. Sugar.
83. Kin. Winding a watch.
84. Aud. Fire engine.
85. Vis. Locomotive.
86. Tac. Coin lying in the hand.
87. Kin. Running.
88. Aud. Piano note.
89. Olf. Freshly popped corn.
90. Vis. Features of lecturer last class lecture.
91. Kin. Stooping to tie a shoe string.
92. Aud. Voices of the members of your family.
93. Kin. Waving your hand.
94. Vis. Dog.

95. Aud. Automobile horn.
96. Kin. Putting on a hat.
97. Aud. Ticking of a watch.
98. Kin. Biting hard candy.
99. Olf. Smoke from an engine.
100. Aud. Horse trotting on a pavement.
101. Vis. Coat.
102. Kin. Opening a book.
103. Aud. Thunder.
104. Olf. Aroma of coffee.
105. Aud. Sound of hammering.
106. Gus. Pineapple.
107. Aud. Bird.
108. Vis. Squirrel.
109. Olf. Tobacco smoke.
110. Kin. Throwing a book on a table.
111. Tem. Hot food in the mouth.
112. Tac. Velvet.
113. Kin. Shelling peanuts.
114. Aud. Throwing a book on a table.
115. Gus. Nuts.
116. Kin. Opening a pocket knife.
117. Vis. Pocket knife.
118. Olf. Odors from a kitchen.
119. Aud. Crying child.
120. Tem. Heat, warm dish held in the hand.
121. Gus. Something bitter.
122. Aud. Shelling peanuts.
123. Vis. Knife and fork.
124. Tem. Heat, hand in hot water.
125. Kin. Using knife and fork.
126. Tac. Pain, from bruise or strain.
127. Vis. Bird.
128. Tac. Sandpaper.
129. Vis. Shelling peanuts.
130. Kin. Closing a door.

Test 2. Visualization

(See Chapter III for instructions.)

1. My house faces the street. If a boy passes my house in the morning, walking toward the rising sun, with my house at his right, which direction does my house face?[1]

2. From the right end of the line AB, draw a line BC at right angles to AB and half as long as AB; from C draw the line CD, three times as long as BC, and through the middle of AB. Join

[1] From Kelly's Silent Reading Test.

A and D. What kind of figure, and how many, are formed by the lines?

3A. Think of a square. From the middle of the top line draw a line to the center of the square. From the middle of the right-hand side draw a line to the center of the square. What do you have?

3B. Now divide all of the large square not included in the smaller square, into five triangles. What lines do you draw to do this?

3C. Now divide the same area into four right triangles. What lines do you draw?

4A. A three-inch cube, painted red, is sawed into one-inch cubes. How many of the little cubes have paint on three faces?

4B. How many have paint on just two faces?

4C. How many have paint on just one face? [2]

5. Draw a vertical line AB with B at the top. From B and toward the right draw a line BC at a right angle to AB, and at the same length as AB. From C draw a line CD, extending above BC, and drawn so D will be equidistant from B and C. Join D and A. What do you have?

6. Think of a triangle. Draw a line from the middle of the left side to the middle of the right side. Draw the two diagonals of the original rectangle. Into how many parts is the rectangle divided?

7A. Think of a square. Draw two horizontal lines through the square, dividing it into three equal rectangles. Draw the two diagonals of the square. Into how many parts is the square now divided?

7B. How many of the parts are triangles?

(Below are four additional problems, given to Group D only).

8A. Think of a triangle. From the center draw a line to any one of the corners. Also draw lines from the center to the middle of each of the three sides. Into how many parts is the triangle now divided?

8B. How many of the parts are triangles?

[2] 4A, 4B, 4C, were taken from Betts.

9A. Think of a square. From the center of the square draw lines to each of the lower corners. From the middle of the bottom line draw lines to each of the upper corners. Into how many parts is the square now divided?

9B. How many of the parts are triangles?

Test 3. Clearness: Fluctuation

(See Chapter IV for instructions.)

The objects to be imagined were:

Circle	Triangle	Square
Rose	Flag	Chrysanthemum

Test 4. Dominance of Concrete Imagery

(See Chapter V, p. 27, for instructions.)

1. Dog
2. Street car
3. George Washington
4. Steam
5. Cornet
6. Umbrella
7. Purity
8. Tennis
9. Napoleon
10. Flies
11. Battle
12. Sparrow
13. Piano
14. Machine
15. Book
16. Lamp
17. Forest
18. Squirrel
19. Writing
20. Chimes
21. Expansion
22. Thunder storm
23. Sleighing
24. Delivery wagon
25. Fourth of July
26. Theater
27. Fan
28. Mosquito
29. Bicycle
30. Postage stamp
31. Hail stones
32. Newspaper
33. Walking
34. Frog
35. Cough
36. Coat
37. Fountain pen
38. Clock
39. Bird
40. Fire-engine
41. Music
42. Onion
43. Picnic
44. Telephone
45. Apple
46. State Street
47. Knife and fork
48. Flashlight
49. Whistle
50. Storm
51. Key
52. Air plane
53. Waterfall
54. Football game
55. Kerosene
56. Hammer
57. Wind
58. Robin
59. Breakfast
60. Pop corn
61. Candy
62. News boy
63. Medicine
64. Running
65. Iron
66. Fire
67. Skating
68. Typewriter
69. Gymnasium
70. Toothbrush
71. Scissors
72. Orange
73. Fur
74. Shoe
75. Mercury

Sentences and Phrases.

1. A boy tooting a horn.
2. A bootblack blacking shoes.
3. A band marching and playing.
4. An athlete making a high jump.
5. A woman putting on her hat.
6. A musician playing a piano.
7. A carpenter driving a nail.
8. A man shoveling snow.
9. A girl talking on a telephone.
10. A hunter shooting at a rabbit.
11. A woman cutting paper with scissors.
12. A stenographer using a typewriter.
13. A group of children playing in a park.
14. A man ringing a bell.
15. A man mowing a lawn.
16. A train pulling out of a station.
17. A street car turning a corner.
18. A dog barking at an automobile.
19. A child carrying a basket.
20. A boy putting on his coat.
21. The driver was whipping the horses.
22. The child screamed and ran to his mother.
23. The storm destroyed the village.
24. The janitor closed the door.
25. The patient was coughing violently.
26. The explosion wrecked the building.
27. Some one using a vacum cleaner.
28. The waiter dropped the tray of dishes.
29. Boys kicking a tin can.
30. To the right the battle raged furiously.
31. A butcher sawing meat.
32. A child opening an umbrella.
33. The wind blowing across the campus.
34. A crowd going to a football game.
35. A woman pumping water.
36. A man shoveling coal.
37. A telegrapher sending a message.
38. Reading in the library.
39. Pushing an electric light button.
40. Unlocking a door.
41. A shell exploding over the city.
42. A policeman blowing his whistle.
43. An audience applauding a speaker.
44. A boy combing his hair.
45. A jeweler winding a clock.
46. A crowd celebrating a football victory.
47. Soldiers drilling on the street.
48. The close of a class lecture in psychology.
49. A newsboy selling papers.
50. Rain beating against the window.

Test 5

(See Chapter VI for material and instructions.)

Test 6

(See Chapter VII for instructions)

	Series 1	Series 2
1.	q s d 5 r o	2 a c y f 4
2.	d p y i g v	h q 8 k 0 2
3.	y 2 f w 4 h	r 4 k 6 x p
4.	c z p 3 t d	p v y w d 3
5.	h n r 3 i 7	u k 4 e y w
6.	f n s x 8 h	v 3 g z 4 p
7.	n g u 4 k i	7 r t q w j
8.	v 6 c g j e	a 9 h k n s
9.	w k r t 9 f	f 6 w 2 y 0
10.	1 s x n 7 f	d t g 5 e c
11.	c j b 4 q x	w 2 y m 4 b
12.	u 2 q a h 8	n 7 f s p x
13.	h 1 4 y 6 0	8 r q w 5 s
14.	d b 3 p v 9	1 x m v 3 g
15.	r 9 q h x p	u 4 r w y f
16.	n t 2 m f n	v g 9 p d 5
17.	d y 8 m 2 w	i h s 6 u w
18.	8 k q a h j	f 2 t 7 c p
19.	4 d 6 u f k	j y 4 b f 6
20.	z 6 c p d t	k j 5 a 8 h

Test 7

(See Chapter VIII for instructions)

The material below is given in the order in which it was presented. In each series the odd numbers are unlike-sounding, the even numbers like sounding.

	Series 1	Series 2	Series 3
1.	6 m j 5 b x 4 q	2 a 6 y f 4 z o	o 6 f 2 a y p a
2.	k 8 o a u q 2 h	h q a 8 k o u 2	k u o q 8 h 2 a
3.	d r 6 u w h s i	k 4 9 r 6 p x q	j 6 r d 9 x q 4
4.	9 w d y i v 3 p	p v y w 9 d i 3	g c 3 i w d 9 y
5.	o 4 z 9 a 6 f 2	u k 4 e 6 y n w	w n k 6 y 4 e u
6.	e g v t c 3 p d	v 3 e g 4 z 6 p	p t d g 6 e y c
7.	w i q r 8 f t 9	7 r t q o w i j	r b j 7 i q w o
8.	f 7 k h n j s 8	a 9 h 7 f k n s	q k a 8 h f 7 n
9.	y c i a 2 w 4 f	f 6 w j 2 c y o	6 w o 2 y f j p
10.	c g 3 e 6 t p v	d t g 5 e y c p	e v 3 z c b 6 g
11.	6 e o 4 n k i u	w 2 y m 4 j b 6	y w 4 j 2 m 6 b
12.	1 f 4 s p 7 x n	n 7 f s 1 9 p x	f n 7 1 s p 4 x
13.	q d r 1 5 w s j	8 r 1 d q w 5 s	1 r 8 q w s 5 d
14.	m v 3 y g 1 5 b	5 1 x m v 3 g b	m x 1 7 b g 3 v
15.	4 w r n y v 8 u	u 4 r w y d f 8	u 8 z 5 f 4 w r
16.	v 9 d p c g 5 y	y v g 9 p d i 5	i q c 9 j 6 g k
17.	i r p 9 q 4 x k	i h r s 6 u w d	s w u 6 r e y h
18.	c 7 b t e 2 m f	f 2 t 7 c p b m	t 3 p c 7 b f m
19.	1 b x u 6 y o j	j y 4 u b f o 6	b j 4 u n 6 y o
20.	a 5 i k y j h 8	k j 5 a 8 i y h	h k 5 i q 8 a j

APPENDIX II.

TABLE A.

	Test 1			Test 4			Test 5				Test 2
Subj.	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	I–S.	Time
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1w	97	66	53	57	24	13	36	32	32	64	
2m	100	98	97	68	21	5	55	32	13	45	
3w	85	53	84	61	8	24	19	13	32	45	
4w	95	90	78	48	28	12	27	33	25	58	
5m	70	65	33	61	26	9	54	22	17	39	
6m	78	55	25	80	9	3	41	37	15	52	
7m	90	67	53	78	15	5	27	34	25	59	
8m	77	59	49	69	10	17	64	16	20	36	
9m	86	31	48	74	7	12	43	3	24	27	
10m	95	26	25	83	3	8	54	15	32	47	
11w	81	86	44	42	35	9	57	28	12	40	
12m	77	89	57	63	29	1	16	60	24	84	
13w	77	90	73	46	34	6	57	38	5	43	
14w	85	58	68	54	8	26	29	30	40	70	
15w	75	65	55	51	33	8	42	41	17	58	
16w	67	66	49	53	32	6	55	26	19	45	
17m	..	..	..	74	10	7	43	30	27	37	
18m	95	83	41	72	14	9	50	34	9	43	
19m	92	69	49	67	23	3	36	44	20	64	
20m	85	47	17	65	18	3	50	38	12	50	
21m	97	79	43	80	14	4	48	0	47	47	
22m	87	22	20	88	8	2	47	13	41	54	
23m	79	47	46	51	16	6	47	23	16	39	
24w	98	81	69	66	26	3	54	22	22	43	
25m	63	57	31	67	23	3	53	13	13	26	
26m	75	0	59	82	1	17	55	15	31	46	
27m	84	77	83	47	28	13	25	16	59	75	
28m	..	..	..	75	22	2	35	39	25	64	
29m	..	..	..	75	15	7	33	23	45	68	
30w	68	55	38	44	27	16	40	34	27	61	
31m	85	57	43	68	23	5	61	20	20	40	
32m	..	..	..	72	17	5	25	36	39	75	
33w	..	..	..	45	31	16	14	69	17	86	
34w	94	63	40	62	23	8	7	47	46	93	
35m	81	57	47	52	13	12	29	33	39	72	
36w	99	75	72	56	26	13	36	52	12	64	
37m	..	..	..	82	13	1	40	46	15	61	
38m	100	99	25	66	25	4	43	39	19	58	
39m	100	66	32	70	16	9	40	31	16	47	
40m	95	92	87	57	21	14	36	38	26	64	
41m	83	79	90	63	22	13	34	31	22	53	892
42w	96	88	98	67	8	17	36	17	33	50	1441
43m	86	76	67	45	36	13	27	37	25	62	2030
44m	72	68	70	57	26	13	17	27	23	50	404
45w	86	93	97	37	24	33	29	36	26	62	600
46w	82	46	23	66	20	5	67	15	11	26	3036
47w	74	73	71	45	32	10	31	28	27	55	895
48w	82	76	67	49	25	19	38	43	19	62	1800
49m	99	81	51	83	10	4	26	38	24	62	2785
50m	87	64	73	66	16	14	50	15	28	43	885
51w	99	82	97	83	12	2	17	38	38	76	582

TABLE A. (CONTINUED)

	Test 1			Test 4			Test 5				Test 2
Subj.	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	I–S.	Time
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
52m	76	67	57	73	15	5	34	33	29	62	1595
53m	99	70	81	70	15	9	58	29	9	38	389
54m	98	61	58	77	18	3	46	29	19	48	1800
55m	97	69	72	71	19	7	17	35	44	79	1070
56w	46	24	79	29	13	28	22	20	40	60	1760
57m	81	64	66	61	18	16	15	47	34	81	1535
58w	83	40	55	57	29	7	24	33	27	60	3015
59w	98	86	59	61	31	5	11	48	23	71	802
60w	100	89	78	77	13	8	31	34	16	50	680
61m	97	74	67	63	24	9	55	18	11	29	1480
62m	81	75	73	51	20	28	15	30	42	72	912
63m	89	76	62	60	25	14	15	36	33	69	1500
64m	91	60	50	80	17	3	57	15	21	36	680
65m	100	86	17	96	3	0	33	36	20	56	303
66m	84	78	78	44	31	22	36	32	23	55	1260
67w	87	35	43	77	5	16	20	36	38	74	2412
68m	..	..	..	83	16	1	24	24	50	74	595
69w	58	87	45	36	48	11	10	67	22	89	361
70w	..	..	..	55	33	12	24	30	38	67	2225
71m	100	88	87	54	35	11	36	28	34	62	410
72w	..	..	..	49	25	26	36	17	43	60	945
73w	..	..	..	51	31	19	24	26	31	57	383
74w	72	57	67	61	29	9	62	20	12	32	1765
75w	81	60	57	55	25	17	17	51	21	72	1545
76w	96	92	39	58	37	6	38	48	10	58	867
77m	74	69	68	57	33	7	15	18	54	72	1861
78m	..	..	..	53	29	22	31	22	26	48	1136
79m	..	..	..	56	30	15	29	29	28	57	325
80m	85	51	85	59	23	16	53	15	28	43	456
81m	92	90	66	59	34	5	38	27	38	65	987
82m	15	27	100	6	10	79	0	0	98	98	2460
83m	..	..	..	56	25	18	17	40	24	64	575
84m	100	97	76	63	28	8	52	20	7	27	1067
85w	75	60	43	52	29	14	41	48	7	55	654
86m	..	..	..	55	27	18	38	33	18	51	3548
87m	91	76	62	56	25	16	15	48	19	67	836
88m	87	71	36	52	31	16	24	61	14	75	2127
89m	..	..	..	58	25	13	34	36	14	50	473
90m	..	..	..	62	22	15	36	31	20	50	843
91m	74	56	73	53	23	21	43	22	28	50	979
92m	..	..	..	45	20	35	31	22	30	52	836
93m	..	..	..	60	22	15	36	36	26	62	868
94w	98	82	57	57	29	7	22	35	16	50	530
95m	86	78	63	50	23	26	31	29	28	57	1070
96w	..	..	..	56	29	10	34	26	22	48	1279
97w	73	64	70	56	30	11	27	62	7	69	710
98m	91	89	77	57	31	8	31	31	36	67	764
99w	97	69	78	51	31	14	20	19	48	67	879
100w	73	56	54	46	33	14	48	21	17	38	1782
101m	..	..	..	44	28	26	24	35	27	62	947
102m	88	76	74	52	25	21	31	19	29	48	1188
103m	92	90	56	47	27	19	27	45	27	71	1109
104w	..	..	..	35	37	25	41	24	26	50	804

TABLE A. (CONTINUED)

	Test 1			Test 4			Test 5				Test 2
Subj.	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	I–S.	Time
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
105m	85	80	76	71	22	6	31	40	17	57	503
106w	93	88	89	57	27	13	38	37	12	48	3070
107m	..	..	..	63	28	7	24	50	19	69	617
108m	..	..	..	39	45	11	55	33	8	41	1227
109m	76	69	62	65	28	5	48	30	18	48	1165
110w	97	78	66	63	28	9	29	34	38	72	555
111m	..	..	..	42	35	20	46	21	27	48	2213
112w	..	..	..	50	31	15	15	57	12	69	1588
Mean	85.3	68.6	60.4	59.7	23.1	12.2	34.9	31.4	25.7	57	1218
Median	86	69	62	58	25	11	35	32	24	57	963
S. D.	13.3	19.0	20.0	13.6	9.0	9.7	14.1	12.6	13.1	14.4	744.3
V.	.16	.28	.33	.22	.39	.80	.41	.41	.51	.26	.61
Range	15–100	0–99	17–100	6–96	1–48	0–79	0–67	0–69	5–98	26–98	303–3548

TABLE B

		Test 6									
		Introspections					U–L			U–L U	Test 7 U–L
Subject	Test 3	Vis.	I–S.	Mea.	Aud.	Kin.	S	A	S+A	S+A	A
1	2	3	4	5	6	7	8	9	10	11	12
1w	B	3	4		5	2	.9	.9	1.8	19	
2m	C	3	4		3	4	3.5	.9	4.4	40	
3w	B		4	3	1	6	–1.4	.9	– .5	1	
4w	A	2	5		5	2	2.5	.7	3.2	41	
5m	B	4	3		5	2	.3	1.6	1.9	19	
6m	A	2	5		5	2	2.5	.8	3.3	31	
7m	C	1	6		3	4	1.7	.5	2.2	23	
8m	C	4	3		2	5	–1.1	– .3	–1.4	–15	
9m	C	2	5		3	4	2.7	1.4	4.1	40	
10m	C	2	5		3	4	.0	1.8	1.8	16	
11w	B	4	3		5	2	3.8	.3	4.1	38	
12m	B		7		6	1	2.0	1.6	3.6	46	
13w	B	2	5		5	2	3.2	2.1	5.3	55	
14w	D	2	5		1	6	–1.4	–1.1	–2.5	–25	
15w	A	2	5		5	2	4.4	1.1	5.5	56	
16w	C	4	3		5	2	.5	.4	.9	13	
17m	E	1	6		3	4	.9	– .7	.2	2	
18m	A	6	1		4	3	– .1	– .1	– .2	– 2	
19m	A	2	5		5	2	.8	1.1	1.9	25	
20m	B	5	2		5	2	– .7	2.0	1.3	7	
21m	C	3	4		2	5	1.3	2.9	4.2	39	
22m	D	3	4		2	5	.2	– .1	.1	1	
23m	C	4	3		4	3	2.1	– .4	1.7	19	
24w	C	4	3		3	4	.6	– .8	– .2	– 2	
25m	A	5	2		4	3	– .1	.3	.2	2	
26m	D	1	6		2	5	.1	.6	.7	10	
27m	B	1	6		2	5	1.3	.4	1.7	18	
28m	B	1	6		4	3	4.5	1.0	5.5	29	
29m	C		7		4	3	3.4	1.6	5.0	40	
30w	A	4	3		4	3	.2	.4	.6	6	
31m	A	5	2		3	4	– .5	.8	.3	5	
32m	D	2	5		4	3	1.5	.7	2.2	21	
33w	C		7		5	2	1.5	1.8	3.3	44	
34w	C		7		5	2	1.5	1.1	2.6	24	
35w	C	2	5		4	3	2.1	1.7	3.8	47	
36w	B	2	5		3	4	–1.4	.1	–1.3	–15	
37m	B	4	3		5	2	2.3	.8	3.1	34	
38m	A	2	5		4	3	.0	.0	.0	0	
39m	A	1	2	4	4	3	– .9	–1.9	–2.8	–34	
40m	B	3	4		3	4	.0	– .2	– .2	– 2	
41m	A	2	4	1	4	3	.1	1.0	1.1	10	0
42w	C	3	4		3	4	.3	.0	.3	4	14
43m	C	3	4		4	3	.1	.3	.4	4	16
44m	A	1	4	2	4	3	–1.5	– .7	–2.2	29	7
45w	B		4	3	5	2	.7	1.2	1.9	21	0
46w	C	5	1	1	5	2	.4	– .1	.3	3	13
47w	C	2	3	2	4	3	1.3	– .5	.8	21	17
48w	B	6	1		3	4	–2.1	–1.3	–3.4	–31	18
49m	C	2	5		4	3	.5	1.3	1.8	18	16

TABLE B (CONTINUED)

		Test 6									
		Introspections					U–L			U–L U	Test 7 U–L
Subject	Test 3	Vis.	I–S.	Mea.	Aud.	Kin.	S	A	S+A	S+A	A
1	2	3	4	5	6	7	8	9	10	11	12
50m	A	3	3	1	3	4	–1.0	–1.0	–2.0	–23	9
51w	A		7		4	3	2.1	.8	2.9	56	9
52m	B		7		4	3	2.9	2.0	4.9	50	2
53m	A	6	1		6	1	.8	.1	.9	14	17
54m	C	4	3		5	2	– .6	.2	– .4	– 5	11
55m	B		7		3	4	2.4	.2	2.6	17	15
56w	C		7		2	5	2.9	1.7	4.6	61	16
57m	B		7		4	3	3.1	2.2	5.3	51	17
58w	B	2	4	1	4	3	1.3	.5	1.8	19	7
59w	C		3	4	5	2	2.6	– .2	2.4	49	5
60w	A	1	2	4	5	2	–3.0	–1.0	–4.0	–32	6
61m	B	4	1	2	5	2	– .8	.2	– .6	– 6	24
62m	B		5	2	3	4	.2	.7	.9	10	8
63m	C		3	4	4	3	–1.0	.9	– .1	– 6	18
64m	A	5	2		5	2	.7	– .8	– .1	5	2
65m	A	2	5		5	2	.9	1.8	2.7	28	25
66m	D	3	4		4	3	.6	3.3	3.9	38	12
67w	C		5	2	4	3	.8	1.5	2.3	25	30
68m	A	4	3		3	4	1.7	.4	2.1	21	5
69w			7		5	2	1.4	1.8	3.2	43	13
70w		2	4	1	3	4	.3	– .2	.1	0	3
71m		5	2		4	3	.9	.0	.9	18	5
72w		5	2		2	5	1.1	– .3	.8	7	19
73w		2	2	3	6	1	.1	– .2	– .1	0	8
74w		3	4		4	3	.2	1.5	1.7	20	15
75w		3	2	2	4	3	2.4	1.4	3.8	58	11
76w		2	5		5	2	1.1	1.7	2.8	26	5
77m		1	3	3	2	5	– .7	.6	– .1	0	8
78m		2	2	3	4	3	.2	1.5	1.7	19	5
79m		4	2	1	5	2	1.9	1.0	2.9	39	18
80m		3	4		3	4	3.0	1.6	4.6	68	7
81m		1	6		4	3	1.5	4.2	5.7	60	13
82m			7			7	–1.8	2.8	1.0	18	6
83m			4	3	5	2	.7	.4	1.1	16	14
84m		4	2	1	5	2	.6	.4	1.0	14	– 5
85w		2	5		6	1	3.1	2.2	5.3	62	18
86m		3	2	2	4	3	1.5	2.5	4.0	42	12
87m		2	4	1	2	5	2.4	.7	3.1	37	6
88m		2	5		5	2	1.2	.4	1.6	33	10
89m			3	4	6	1	.7	– .7	.0	12	10
90m		1	4	2	5	2	.0	1.0	1.0	10	12
91m		5	2		4	3	1.0	1.4	2.4	22	17
92m			4	3	3	4	1.5	2.4	3.9	40	– 5
93m			6	1	4	3	.5	.8	1.3	14	13
94w			1	6	5	2	1.1	– .2	.9	12	6
95m		2	1	4	1	6	.3	.9	1.2	15	14
96w			3	4	5	2	.9	.4	1.3	14	8
97w			7		6	1	10.3	1.6	11.9	97	17
98m		2	5		4	3	3.5	2.8	6.3	69	12

TABLE B (CONTINUED)

		Test 6									
		Introspections					U–L			U–L U	Test 7 U–L
Subject	Test 3	Vis.	I–S.	Mea.	Aud.	Kin.	S	A	S+A	S+A	A
1	2	3	4	5	6	7	8	9	10	11	12
99w		2	3	2	2	5	– .1	.1	.0	0	9
100w		4	3		2	5	2.3	1.1	3.4	63	20
101m			5	2	5	2	1.9	1.8	3.7	53	1
102m		2	4	1	2	5	1.8	2.1	3.9	56	5
103m		3	4		4	3	1.3	.7	2.0	28	26
104w			6	1	6	1	1.8	.8	2.6	29	17
105m		1	4	2	5	2	.9	.9	1.8	35	14
106w			6	1	6	1	1.1	1.0	2.1	33	8
107m		2	5		6	1	.2	.5	.7	9	25
108m		1	5	1	6	1	.5	1.0	1.5	20	– 5
109m		4	3		4	3	1.5	1.7	3.2	34	8
110w			7		3	4	1.4	3.5	4.9	45	23
111m		2	4	1	4	3	.8	.3	1.1	25	13
112w		1	5	1	5	2	1.5	1.7	3.2	45	11
Mean		2.1	4.1	0.8	4	3	1.06	0.83	1.9	22	11.1
S.D.		1.2	1.7	1.3	1.3	1.3	1.63	1.04	2.25	23.8	7.3
V.		.57	.41	1.6	.33	.40	1.54	1.25	1.18	1.08	.66
Range		0–6	1–7	1–6	0–6	1–7	–3– 10.3	–1.9– 4.2	–4– 11.9	–34– 97	–6– 30

TABLE C

Separate Scores for Each Problem of Test 2

1	2	3	4	5	6	7	8
1	0.0	38.5	27.0	38.5	27.0	22.6	.59
2	5.5	72.3	60.0	85.2	63.0	46.6	.55
3A	0.0	21.3	15.0	21.3	15.0	10.7	.50
3B	4.1	91.0	70.0	101.3	72.0	57.2	.56
3C	13.7	70.5	30.0	102.2	43.0	89.0	.87
4A	12.3	97.6	70.0	123.6	95.0	77.3	.63
4B	24.7	102.0	80.0	152.0	120.0	93.0	.61
4C	11.0	51.3	20.0	78.0	26.0	80.0	1.03
5	8.2	84.6	70.0	102.3	75.0	55.2	.54
6	0.0	45.0	29.0	45.0	29.0	26.8	.60
7A	21.9	92.5	73.0	138.0	115.0	92.3	.67
7B	16.4	61.0	51.0	101.3	55.0	85.0	.84
8A	0.0	60.0	45.0	60.0	45.0	32.4	.54
8B	0.0	32.7	12.0	32.7	12.0	28.8	.88
9A	0.0	79.0	63.0	79.0	63.0	38.0	.48
9B	6.8	46.0	38.0	68.0	38.0	52.0	.77

Column 1, number of problems.
Column 2, per cent of failures.
Column 3, mean scores, excluding failures.
Column 4, median scores, excluding failures.
Column 5, mean scores, including failures counted as 300 seconds.
Column 6, median scores, including failures.
Column 7, average deviation, including failures.
Column 8, average deviation divided by mean, failures included.

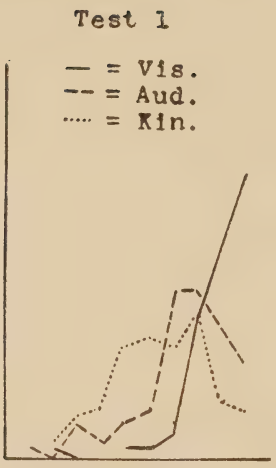
These figures are based on the results for 74 subjects for problems 1 to 7B, and for 44 subjects for problems 8A to 8B. Two of these subjects did not take the rest of the tests.

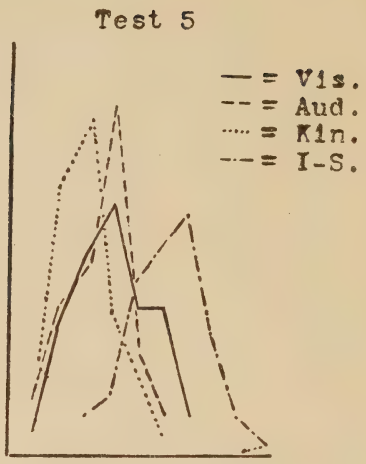
TABLE D

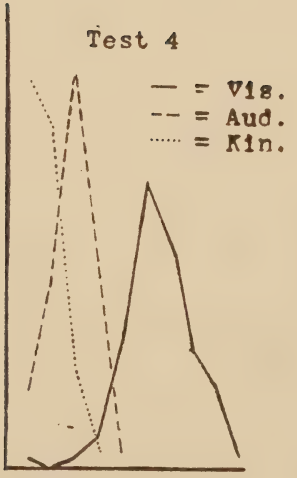
Correlations

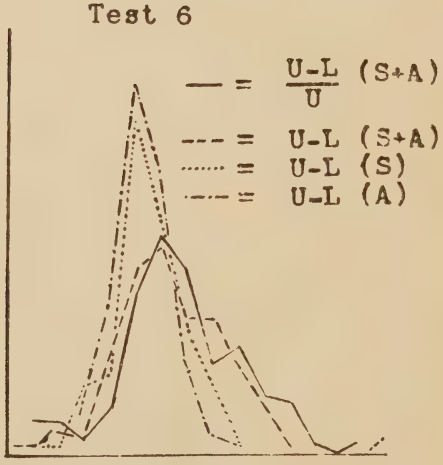
	Test 1			Test 4			Test 5				Test 2	Test 6	
	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	Vis.	Aud.	Kin.	I–S.		U–L (S+A)	$\frac{U-L}{U}$ (S+A)
Test 1													
Vis.	...	.46	–.01	.58	...	...	.12	...	...	–.14	.27	–.16	–.17
Aud.	.46	...	.30	...	.51	...	...	.42	...	.14	.45	.10	.04
Kin.	–.01	.30	...	...	...	.43	...	...	.29	.17	.17	.03	.07
Test 4													
Vis.	.58	...	...	...	–.63	–.68	.27	...	...	–.21	.12	–.10	–.18
Aud.	...	.51	...	–.63	...	–.02	...	.38	...	.10	–.02	.18	.23
Kin.	...	...	.43	–.68	–.02	...	...	...	.49	.25	–.14	–.07	–.01
Test 5													
Vis.	.12	...	...	.27	...	...	...	–.44	–.49	–.84	–.06	–.13	–.16
Aud.	...	.42	...	...	.38	...	–.44	...	–.40	.55	.11	.26	.28
Kin.	...	...	.29	...	...	.49	–.49	–.40	...	.55	–.07	–.01	–.02
I–S.	–.14	.14	.17	–.21	.10	.25	–.84	.55	.55	...	.03	.22	.22
Test 2	.27	.45	.17	.12	–.02	–.14	–.06	.11	–.07	.03	...	.05	.07
Test 6													
U–L (S+A)	–.16	.10	.03	–.10	.18	–.07	–.13	.26	–.01	.22	.05	...	.95
$\frac{U-L}{U}$ (S+A)	–.13	.04	.07	–.18	.23	–.01	–.16	.28	–.02	.22	.07	.95	...

APPENDIX III









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